GARDENS, WILDLIFE DENSITIES, AND SUBSISTENCE HUNTING BY MAYA INDIANS IN QUINTANA ROO, MEXICO

By

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My Best Friend,
My Wife

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GARDENS, WILDLIFE DENSITIES, AND SUBSISTENCE HUNTING BY MAYA INDIANS IN QUINTANA ROO, MEXICO

By

Jeffrey Paul Jorgenson

December 1993

Chairman: Dr. Kent H. Redford
Major Department: Forest Resources and Conservation

Subsistence hunting by Maya Indians was studied at Ejido X-Hazil y Anexos, Quintana Roo, Mexico, during 1989-1990. These highly acculturated Indians have hunted and planted gardens in the Yucatán Peninsula for several thousand years. The goal of this study was to evaluate the premises of "garden hunting." This kind of hunting is a special mammal harvesting pattern based on interactions between hunters, who plant gardens and harvest game, and game species that eat crops and have greater population densities in the vicinity of gardens than in forest areas without gardens. The specific objectives included the following: (1) determine game harvest patterns by Maya subsistence hunters; (2) compare wildlife densities in three forest successional stages; (3) determine the kinds and amounts of crops consumed by game species; and (4) characterize Maya gardens and their use by wildlife. Maya hunters harvested eight species of mammals and four species of birds as game. A total of 584 animals were harvested by 88 hunters during 17 months. The coati (*Nasua nasua*) and plain chachalaca (*Ortalis vetula*) were the most frequently harvested taxa (167 individuals each). Game was harvested throughout the year and frequently was taken in areas associated with shifting cultivation. Wildlife densities were low compared with those at other Neotropical forest sites, and significant differences in wildlife density among three forest successional stages by species, taxonomic group, and game or nongame status generally were not observed. The average garden size was 2.1 ha in 1989 and 2.7 ha in 1990 (maximum size was 18.0 ha). Sixteen crops were planted by Maya gardeners, of which six crops were consumed by game species. Corn, kidney beans, and squash were most frequently planted. Corn was the most frequently eaten crop (25.4% of 284 stomach samples). Four game species were the primary consumers of crops: paca (*Agouti paca*), agouti (*Dasyprocta punctata*), coati, and collared peccary (*Tayassu tajacu*). These game species were among the most frequently taken taxa by number of individuals and total body weight. Given that wildlife populations generally were not greater in the vicinity of gardens, these results generally do not support the premises of garden hunting. These results also suggest that an effective wildlife management program should be implemented in order to ensure the survival of these wildlife species and the cultural traditions of the Maya hunters.

Resumen de Disertación para la Escuela de Postgrado de la
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MILPAS, DENSIDADES DE VIDA SILVESTRE Y CACERIA DE SUBSISTENCIA
POR LOS INDIGENAS MAYAS EN QUINTANA ROO, MEXICO

Por

Jeffrey Paul Jorgenson

Diciembre de 1993

Director: Dr. Kent H. Redford
Departamento: Recursos Forestales y Conservación

La cacería de subsistencia por los indígenas mayas fue estudiada en el Ejido de X-Hazil y Anexos, Quintana Roo, México, durante 1989-1990. Esta gente, bastante modernizada, ha cazado y cultivado milpas en la Península de Yucatán por miles de años. El objetivo de este estudio fue evaluar las teorías acerca de la cacería de "parcela agrícola" de subsistencia. Esta clase de cacería de mamíferos es un tipo especial de explotación basado en las interacciones entre los cazadores, que siembran las parcelas, y los animales y especies cinegéticas, que se alimentan de los cultivos y tienen densidades poblacionales grandes alrededor de las parcelas en comparación a las áreas forestales sin parcelas. Los objetivos específicos incluyeron: (1) determinar los patrones de la caza de animales; (2) comparar las densidades de los animales en tres estados sucesionales del bosque; (3) determinar las clases y las cantidades de cosechas consumidas por los animales cinegéticos; y (4) caracterizar las parcelas agrícolas y su uso por los animales. Los cazadores mayas cazaron ocho especies de mamíferos y cuatro especies de aves. Un total de 584 animales fueron cazados por 88 cazadores durante 17 meses. El tejón (*Nasua nasua*) y la chachalaca (*Ortalis vetula*) fueron las especies cazadas con más frecuencia (con 167 individuos cada una). Hubo cacería a lo largo del año y con frecuencia los animales fueron cazados en áreas de agricultura de roza, tumba y quema. Las densidades de animales fueron bajas, comparadas con otras áreas forestales neotropicales, y no se observaron diferencias significativas en la densidad de los animales por especie, grupo taxonómico, o estado cinegético o no cinegético en tres áreas forestales en estado sucesional diferente. El tamaño promedio de las milpas fue de 2.1 ha en 1989 y 2.7 ha en 1990 (el tamaño máximo fue 18.0 ha). Dieciseis especies de plantas fueron cultivadas en las milpas, de las cuales seis fueron consumidas por las especies de cacería. El maíz, frijol, y calabaza fueron los cultivos más comunes. El maíz fue el cultivo más frecuentemente utilizado por los animales (25.4% de 284 muestras estomacales). Cuatro especies cinegéticas fueron los consumidores principales de las cosechas: el tepezcuintle (*Agouti paca*), sereke (*Dasyprocta punctata*), tejón y jabalí de collar (*Tayassu tajacu*). Estas especies fueron las más cazadas tanto por número de animales como por peso total del cuerpo. Dado que las poblaciones de fauna silvestre no fueron mayores alrededor de las milpas, estos resultados en general no apoyan las teorías acerca de las cacería en parcelas agrícolas. Además, estos resultados sugieren que un programa efectivo de manejo de vida silvestre debe ser ejecutado para asegurar la supervivencia de estas poblaciones de vida silvestre y las tradiciones culturales de los cazadores mayas.

CHAPTER 1
OVERVIEW

This dissertation proposes to examine the interrelation between gardens, wildlife densities, and subsistence hunting in a Maya Indian community in southeastern Mexico. The Maya are a rural people and have practiced shifting cultivation for several thousand years. In many regards, they subsist today as they have done for thousands of years by hunting, caring for wild and domestic animals, and by planting crops in their gardens. The Maya, however, have undergone rapid cultural change due to tourism and economic development in the Cancún area and slowly are being incorporated into Mexican political and economic activities.

Subsistence hunting as practiced today by the Maya is unusual when compared with hunting by other indigenous groups in two regards: One, due to the availability of domestic livestock and canned meat, hunters are not dependent upon the game they harvest as a source of food. Two, the Maya have been able to live in permanent settlements and exploit the local wildlife populations apparently without exhausting local wildlife populations, while many other indigenous groups have depleted local wildlife populations and consequently have had to move their settlements repeatedly or undergo seasonal treks (Stearman, 1990; Vickers, 1988, 1991; Werner, 1983). An understanding of how the Maya have been able to continue subsistence hunting for so long, while indigenous peoples in other areas have not been able to do so, will provide important information to biological and social scientists seeking to balance the issues of conservation and economic development.

The research described here was designed to examine the hypothesis that subsistence hunting by Maya Indians may be more than a simple game harvest activity. Rather, Maya subsistence hunting may be part of a complex game-procurement system composed of gardens, wildlife, and hunters. "Garden hunting," described by Linares (1976) for a prehistoric indigenous people in Panama, may actually be the model whereby the Maya have been able to hunt and practice shifting cultivation in the

Yucatán Peninsula for several thousand years. If it can be shown that garden hunting is compatible with sustainable wildlife use, then biological and social scientists will have an important tool in developing management plans that balance the needs of both the hunters and the hunted.

Uses of Wildlife

The importance of wild animals to the Maya and other indigenous people in the Neotropics is best appreciated by noting the benefits obtained from their use. While indigenous groups differ in the species of game animals they take and taboo (prohibit taking for cultural reasons), several broad patterns of wildlife use can be identified. Here I will consider three of the principal uses of game; food, nonedible products, and live animals.

Bushmeat, meat from edible wildlife, is one of the most important uses of wild animals (Dufour, 1983; Flowers, 1983; Yost and Kelley, 1983). A wide variety of fishes, birds, mammals, reptiles, amphibians, and insects are taken in a multitude of habitats by a broad range of people (Beckerman, 1980, 1983; Chernela, 1985; Redford and Robinson, 1987, 1991; Robinson and Redford, 1991a, 1991b, 1991c; Stocks, 1983). Game taken by indigenous people in the Neotropics usually is for subsistence (Lugo et al., 1987; Robinson and Redford, 1991a, 1991b), but meat and eggs of several taxa frequently are also taken for commercial purposes and are sold locally or outside the community. Capybara (*Hydrochaeris hydrochaeris*) meat, which, because of its aquatics habits is actually considered a "fish," is traded commercially in Venezuela during Lent (Ojasti, 1991), while eggs from sea turtles and freshwater turtles (Order Testudines) are taken along the coasts and inland waterways in Brazil and Honduras and sold in local markets (Cornelius et al., 1991; Lagueux, 1991; Smith, 1974).

In addition to the nutritional aspects of meat, game is important for social reasons. Investigators have shown that the type and amount of game obtained is important to a hunter's prestige and the social cohesion of the family or village (Balée, 1985, 1989; Paolisso and Sacket, 1985; Siskind, 1973; Stearman, 1989, 1990). Occasions without meat often are perceived by indigenous people as times of hunger even though plenty of food from plants is available (Werner, 1983).

A second important use of game is to provide nonedible products such as leather, skins, hides, and feathers. Use of skins and hides initially was limited to that by indigenous people to perform rituals, conduct trade with other indigenous groups, and manufacture clothing and artifacts. Today, the use of nonedible products has greatly increased in volume and includes indigenous groups, mestizos, and local and foreign business people.

Much of the trade in leather, skins, hides, and feathers now is for commercial purposes. Most of the recent leather trade for example, has been composed of peccaries (*Tayassu tajacu, T. pecari*; Broad, 1984; Hvidberg-Hansen, 1970), capybaras (Smith, 1981b), and various species of lizards (Suborder Sauria) and crocodiles (Order Crocodylia; Luxmoore, 1988). Until recently, the skin trade was concentrated on a few species of carnivores taken to satisfy the international demand, including giant otter (*Pteronura brasiliensis*), river otter (*Lutra longicaudis*), jaguar (*Panthera onca*), and several smaller feline species (*Felis* spp.; McMahan, 1986). This trade in skins, however, generally has ended due to international restrictions such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Trade in feathers has declined markedly, too, but Aztec and Inca Indians formerly used feathers in capes and artifacts utilized during religious ceremonies (Haemig, 1978). The feather trade today is limited primarily to feathers from rheas (*Pterocnemia pennata* and *Rhea americana*) that are made into dusters (Cajal, 1988).

Other nonedible products obtained from wild animals include guano from bats and birds (Haynes, 1987); oil from reptiles, bird eggs, and manatees (*Trichechus manatus*, and *T. inunguis*; Pereira, 1944; Smith, 1974, 1981a, 1981b); bones, teeth, and claws for tools, handicrafts, and ornamental purposes (March M., 1987; Parra Lara, 1986; Santana et al., 1990); and animal parts used for medicinal and ritual purposes, such as sloth (*Bradypus tridactylus* and *Choloepus hoffmanni*; Romanoff, 1984) and little spotted cats (*Felis tigrina*; Jorgenson and Jorgenson, 1991).

A third principal use of wildlife is as live animals. Both indigenous and nonindigenous people keep many species of live animals as pets. Song birds and parrots commonly are used for this purpose (Beissinger and Snyder, 1991; Iñigo-Elias and Ramos, 1991; Jorgenson and Thomsen, 1987; Thomsen and Braütigam, 1991). Many wild animals originally kept as pets subsequently are eaten, for example, guanaco (*Lama guanaco*; Gilmore, 1950), collared peccary (*Tayassu tajacu*), paca (*Agouti paca*), and agouti (*Dasyprocta punctata*; Jorgenson, pers. obs.).

Another use of live animals from the Neotropics is for the biomedical and zoo trade. Between 1961-1965, for example, 139,000 live primates were exported from Iquitos, Peru (Grimwood, 1969), and in 1973, at least 91,662 primates were exported from Iquitos (Castro, Revilla, and Neville, 1975-76). Reptiles and amphibians also were traded for these purposes. Today, international trade in these species for commercial purposes is strictly regulated.

The studies mentioned above show that 1) many taxa of wild animals are used by settlers and indigenous people, 2) these taxa have many different types of uses, and 3) these uses have occurred over millennia. These facts suggest that wildlife can be used sustainably in some cases. The current rate of human population growth and corresponding decrease in natural habitat, however, suggest that many species of plants and animals will become extinct in the near future as the areas where they occur are converted by humans to areas unable to support the original complement of plants and animals (Meffe et al., 1993; Myers, 1987, 1989; Robinson, 1993; World Resources Institute, 1990). The challenge as conservation biologists is to identify and promote ways in which wild animals can be used sustainably.

Sustainable Use of Wildlife

While studies have shown that some people in the Neotropics appear to use wildlife at sustainable levels (Dufour, 1990; Stearman and Redford, 1992; Vickers, 1991), there also is evidence that other people hunt or capture wildlife at levels that may not be sustainable, especially when these people participate in market economies (Dourojeanni, 1985; Fitzgerald, 1989; Ojeda and Mares, 1984; Redford and Robinson, 1985; Vickers, 1988).

Evidence that people can overexploit local wildlife populations presents a dilemma to many organizations. For example, the United Nations Environmental Programme (UNEP), World Wildlife

Fund-U.S. (WWF-U.S.), World Wide Fund for Nature (WWF), and the International Union for Conservation of Nature and Natural Resources (IUCN) promote the incorporation of settlers and indigenous people into the management of natural areas and local populations of plants and animals (Chicchón, 1992; Di Castri et al., 1981; Halffter, 1981; Redford and Stearman, 1989). However, in view of the willingness of some people in the Neotropics to deplete local wildlife populations by overhunting and habitat alteration, it is critically important that studies be conducted that carefully measure wildlife use and habitat alteration. The purpose of these studies should be to identify sustainable uses of the wildlife and the areas where they occur.

Given that the factors affecting local wildlife and habitat communities vary and that local settlers and indigenous people have different needs, interests, and abilities, several questions need to be considered in a study of sustained use of wildlife, such as subsistence hunting: What are the pressures to overexploit plants and animals? Could market hunting become a problem? Are there any cultural limitations that need to be considered? The results likely will suggest certain basic principles about the sustainability of subsistence hunting, but that people and wildlife in different areas are subject to distinctive factors that affect this activity.

Many anthropological and biological studies about hunting by settlers and indigenous people have been undertaken recently in the Neotropics. These studies are of limited value in evaluating the sustainability of hunting or in generalizing hunting from one site to another because the data were collected for other reasons. Recent anthropological studies in the Amazon Basin, for example, have focused on such topics as wildlife use (Vickers, 1991), optimal foraging (Hames and Vickers, 1982; Hill and Hawkes, 1983), protein consumption (Beckerman, 1979; Gross, 1975), hunting strategies (Paolisso and Sackett, 1985; Saffirio and Scaglion, 1982), and resource availability (Bailey et al., 1989). Recent biological studies have examined such topics as food habits and habitat use of game species (Bodmer, 1989, 1990, 1991), game use by settlers and indigenous people (Ayres et al., 1991; Redford and Robinson, 1987; Vickers, 1991), and the effects of habitat disturbance on wildlife (Johns, 1986, 1988). Taken together, these studies provide much useful information about the nature and extent of human hunting, but they have limited use in applications to other issues.

In order to overcome the limitations of these anthropological and biological studies about hunting and to examine critically the issue of the sustainability of subsistence hunting, integrated studies are needed. These studies must provide data on what kinds of wildlife are hunted and, simultaneously, what kinds of wildlife are potentially available to hunters (Redford and Robinson, 1990).

Garden Hunting

The specific methods of subsistence hunting in the Neotropics vary considerably among groups of indigenous people with respect to species taken, technology used, timing and duration of hunts, and where the hunt is undertaken (cf., Hames and Vickers, 1983) One place where hunting frequently occurs is in the gardens planted by local residents. Hunting in gardens has been described for many indigenous groups, including the Achuara-Jívaro of Peru (Ross, 1978); the Yanomama (Smole, 1976) and Ye'kwana of Venezuela (Hames, 1980); the Lacandon Maya of Mexico (Nations and Nigh, 1980); the Yukpa, along the frontier between Venezuela and Colombia (Ruddle, 1974); the Miskito Indians of coastal Nicaragua (Neitschmann, 1972, 1973); the Sirionó of Bolivia (Holmberg, 1969); and the Kayapó (Posey, 1982, 1985) and Ka'apor (Balée, 1985) of Brazil. In general, these studies have quantified hunting or have described game use, but they have not demonstrated that this game harvest is part a system where the wild animals actually are managed by the local residents.

Linares (1976) was the first to propose that subsistence hunting by indigenous people in the Neotropics was something more than hunters taking wild animals where the wild animals were abundant or easy to harvest. Based on archeological evidence, Linares (1976) proposed that, prior to the arrival of Columbus, indigenous people at Cerro Brujo, Panama, practiced a type of wildlife management in which they planted crops in gardens and hunted the wild animals that fed incidentally on these crops. This game-procurement system, according to an analysis of about 6,000 bones from refuse piles at two occupation sites, appeared to be selective in that only a certain group of terrestrial mammals was taken. Although Linares (1976) did not present information about the occurrence and relative abundance of the other taxa present at the area, she concluded that the number and kinds of animals taken by the hunters were affected by 1) shifting cultivation, especially of cultivated root crops, and 2) the behavioral preadaptation of these mammals to become commensals of people.

Linares (1976) called this hypothetical game-procurement system "garden hunting" and characterized it (p. 344) from two different perspectives:

> One, "The most abundant animals present are either smallish animals that live in the underbrush or in burrows, often in the vicinity of encampments or recently cleared fields (the caviomorph rodent[s] and armadillo), or larger forms that are not too shy and live—or can live—in forest-edge conditions (the collared peccary and the white-tailed deer)."

> Two, "The mammals missing altogether or poorly represented are either those that inhabit the high canopy (monkeys [*Cebus, Ateles, Alouatta*, etc.], sloths [*Bradypus* and *Choleopus*] or those that are fast climbers (coatis [*Nasua nasua*], squirrels [*Sciurus*]) or those that are very shy and live in forested conditions away from man (the brocket deer and tapir [*Tapirus bairdii*]."

The supporting evidence for these characterizations was based on 1) faunal assemblages in Neotropical forests at Suriname and Barro Colorado Island, Panama (Eisenberg and Thorington, 1973) and 2) behavioral and ecological traits of the most important mammals hunted by the prehistoric Cerro Brujo group. Based on a comparison of mammalian biomasses, Linares (1976) determined that none of the dominant species (in terms of biomass) at Surinam or Barro Colorado Island was taken by Cerro Brujo hunters. Linares (1976) hypothesized that this was due to a difference between faunal assemblages among the three areas, and indicated that Cerro Brujo represented a cultural faunal assemblage, whereas Suriname and Barro Colorado Island represented natural or undisturbed assemblages.

Based upon a comparison of behavioral and ecological traits for the terrestrial mammals harvested at Cerro Brujo, Linares (1976) determined that there were differences between closely related species that affected the frequency with which they were harvested. Between peccaries, the white-lipped peccary needs a large home range and probably a large forest, whereas the collared peccary is known to live in disturbed conditions and readily eats cultivated crops. Between deer, the brocket deer is shy and dwells in the forest, whereas the white-tailed deer occurs in cleared and cultivated fields. The collared peccary and white-tailed deer were harvested more frequently by Cerro Brujo hunters than were white-lipped peccaries or brocket deer. The other mammals taken at Cerro Brujo also ate crops or used gardens.

Garden hunting has been described for various indigenous people, but the intensity and nature of these studies has varied. Perhaps one of the most thorough studies of this practice was conducted by Irvine (1987) at a site in the Ecuadorian Amazon that was populated by Runa Indians. Irvine (1987) quantified the take of game with respect to habitat type (i.e., gardens, fallow, and forest). By rank order of frequency of take, the acouchy (*Myoprocta pratti*, 25.6% of kills, total number of kills = 833), agouti (14.0%), paca (13.3%), and squirrels (*Sciurus* spp., 11.1%) were most commonly taken by Runa hunters. By rank order by weight of kills, the paca (25.8%, total weight = 3,439.7 kg), collared peccary (20.4%), agouti (14.1%), and brocket deer (*Mazama* spp., 12.7%) were more common. Among the caviomorph rodents and the large mammals, there were differences in the frequency of game kills by habitat type. For the rodents, the paca (20.8% of kills in gardens, 21.7% of kills in fallows, and 57.5% of kills in forest) and the agouti (15.8%, 32.4%, and 51.8%) readily used gardens and fallows, whereas the acouchy (1.5%, 27.5%, and 70.7% [corrected values from Table 4-5 of Irvine]) readily used fallow and forest, but only infrequently used gardens. For the large mammals, the collared peccary (0.0%, 14.3%, and 85.7% [corrected values from Table 4-5 of Irvine]) and the brocket deer (0.0%, 35.0% and 65.0%) readily used fallow and forest, but did not use gardens.

With respect to whether the Runa practice garden hunting, these results showed that the agouti and paca were both numerically important and frequently harvested in gardens. The acouchy, on the other hand, was numerically important, but did not use gardens. Among the large mammals, the collared peccary and brocket deer were neither numerically important nor harvested in gardens. Both species, however, were harvested in fallow areas. Irvine (1987) concluded that the primary factor responsible for the occurrence of game kill sites in gardens and fallows was not the availability of crops, but rather the occurrence of fruiting trees such as *chunda* (*Bactris gasipaes*) and *sacha abillu* (species undetermined, Family Sapotaceae).

The present research is the first integrated study of garden hunting to demonstrate the possible interdependence between hunting, gardens, and game abundance. In this study, I examine simultaneously wildlife take, wildlife availability, wildlife food habits, and wildlife use of gardens in a single area.

Maya Gardens

Maya gardeners today plant two types of gardens: *milpa* and *solar* (Caballero, 1992; Forrest, 1991). The *milpa* is a relatively large plot of land that is located away from the house. Crops such as corn and beans are planted in these gardens. *Milpas* are moved to new sites every 1-2 y. The *solar* is a relatively small plot that is located around the house or in the immediate vicinity of the house. Fruits, herbs, and medicinal plants are planted in these gardens. *Solares* are not moved from year to year. In this dissertation, the term garden will be used to mean *milpa*.

Research Objectives

The overall research question of this study is the following: "Do Yucatec Maya Indians at Ejido X-Hazil y Anexos, Quintana Roo, Mexico, practice garden hunting?" If Maya subsistence hunting is indeed garden hunting per Linares (1976), I would predict the following: one, wild animals taken as game would use gardens; two, hunters would concentrate their harvest of game on those species of wild animals that used gardens; three, the densities of these wild animals taken as game would be greater in the vicinity of gardens than in forests without gardens; and four, the wild animals taken as game would consume crops from gardens.

In order to evaluate the nature and extent of this hunting, questions were formulated following suggestions by Redford and Robinson (1985, 1990). Fieldwork was conducted during 1989-1990. The results form the basis for the remaining chapters of this dissertation.

In Chapter 2, I discuss the natural, cultural, and socioeconomic environment of the Maya Indians in Quintana Roo, Mexico. This general discussion of the setting will facilitate comparisons with other sites. In Chapters 3-7, I present and discuss specific data collected during the field study.

In Chapter 3, I discuss wildlife harvest by Mayan hunters in Ejido X-Hazil y Anexos. The specific questions answered are:

- How many people in the village hunted?
- How many individuals and what kinds of wildlife were taken by hunters?
- How much wildlife did individual hunters take?
- When, where, and how was wildlife taken?
- What was the catchment area of the hunting?
- Were there temporal or seasonal differences in the frequency at which wildlife was taken?
- In what kinds of habitat were wildlife taken?

This information on wildlife use will be compared with estimates of wildlife population densities presented in Chapter 4.

In Chapter 4, I discuss wildlife densities in early secondary forest (current and recent agricultural areas) versus late secondary forest (areas not used for agriculture for at least 50 y) in the study area. The specific questions answered are:

- How many individuals and what kinds of wildlife were sighted?
- In what kinds of habitat was wildlife observed?

- Were there temporal or seasonal differences in the frequency at which wildlife was sighted?

This information will give a measure of the number and kinds of wildlife potentially available to hunters, and will be compared to wildlife use as described in Chapter 3.

In Chapter 5, I discuss wildlife food habits and evaluate the importance of gardens and domestic crops in wildlife diets. The importance of gardens and crops will be analyzed with respect to wildlife use by hunters (Chapter 3) and wildlife availability (Chapter 4). The specific questions answered are:

- What kinds and what parts of plants were eaten by wildlife?
- Were there seasonal differences in wildlife diets?
- Were cultivated crops important as food to wildlife?

This information will be used to determine if wildlife is attracted to domestic crops or wild plants that occur in gardens as a result of disturbance (e.g., palms).

In Chapter 6 I discuss characteristics of Mayan gardens and their uses by hunters and wildlife. The specific questions answered are:

- How large were gardens?
- What crops were planted in gardens?
- In what habitat types and at what distances from the village were gardens located?
- When were gardens cleared, planted, and harvested?

This information will be used to explain wildlife availability (Chapter 4) and wildlife food habits (Chapter 5).

In Chapter 7, I summarize the results of this study with respect to the model of garden hunting and offer a series of conclusions. I focus on the main premises of Linares (1976): one, wild animals used gardens; two, hunters had to focus their harvest of game on those species of wild animals that used gardens; three, the densities of these wild animals were greater in the vicinity of gardens than in forests without gardens; and four, these wild animals had to consume crops from gardens. This study was designed to test each of these premises. In closing, I will propose that strong conservation measures be enacted to protect the wild animals at X-Hazil Sur and the cultural traditions of the Maya hunters that use these species.

Maya and Spanish Terms

One of the challenges that accompany working in a different culture is being able to translate specific terms into your native language. During this study, many Maya and Spanish terms were learned for gardens, vegetation, and wildlife that did not have equal counterparts in English. In order to enhance clarity, maintain the Maya and Spanish sense of the term, and avoid lengthy and ambiguous English translations in this paper, several Maya and Spanish terms were retained and italicized (e.g., *huaya*).

CHAPTER 2
NATURAL, CULTURAL, AND SOCIOECONOMIC ENVIRONMENT OF THE MAYA INDIANS IN QUINTANA ROO, MEXICO

Introduction

Subsistence hunting in the Neotropics, whether practiced by Maya Indians, peasants, or tribal peoples, varies in response to different natural and cultural factors. Each group, for example, hunts a wide range of wildlife, uses different techniques to locate and kill prey, and observes specific traditions in the use of wildlife and exchange of game. An understanding of these natural and cultural factors will help to explain specific hunting methods and results as well as help to analyze the variation in subsistence hunting practices by these people. A key additional consideration to understanding hunting is the nature and extent to which cultural factors break down when the group becomes involved with market economies. For this dissertation, I will analyze subsistence hunting by Maya Indians in the village of X-Hazil Sur, Ejido X-Hazil y Anexos, State of Quintana Roo, Mexico (the Spanish term *ejido* is used to describe a geographic and administrative unit in Mexico, see below).

The following summary describes published accounts as well as personal observations during 1987 and 1989-1990 of the natural, cultural, and socioeconomic environment of the Maya at the local (village), state (Quintana Roo), and regional level (Yucatán Peninsula). While the personal observations were made primarily in the village of X-Hazil Sur, trips also were made throughout the region. The final section of this chapter is an extensive description of the study area.

The term subsistence hunting, as contrasted with commercial hunting, will be used here to describe hunting by Maya Indians at X-Hazil Sur as game rarely is sold in markets. However, as many Maya hunters care for domestic animals or can purchase canned meat, this hunting has more of an opportunistic quality than, for example, subsistence hunting practiced by Yuquí Indians in Bolivia (cf., Stearman, 1989) or Siona-Secoya Indians in Ecuador (cf., Vickers, 1988).

Natural Environment

Quintana Roo (50,843 km^2) is located along the east coast of the Yucatán Peninsula, between 17°49′-21°37′ N latitude and 86°44′-89°24′ W longitude (Figure 2-1; Escobar Nava, 1986). To the east lies the Caribbean Sea, to the west the Gulf of Mexico and the Mexican states of Yucatán and Campeche, and to the south lie the countries of Belize and Guatemala.

Ecological characterization of Quintana Roo is incomplete. Studies have been conducted on mammals, birds, reptiles, amphibians, vegetation, and soils, but much of this information has not been updated in 30-50 years. Recent studies, however, include a statewide, botanical survey (Cabrera Cano et al., 1982), an ecological assessment of the southern part of the state (Camarena-Luhrs and Salazar-Vallejo, 1991), and an analysis of the biological diversity and economic aspects of the Sian Ka'an Biosphere Reserve (Dachary and Arnaiz Burne, 1989; Navarro L. and Robinson, 1990). The following summary provides information relevant to an understanding of the natural and cultural factors affecting subsistence hunting by Maya Indians in Quintana Roo.

Geology and Physiography

Quintana Roo is a flat, broad shelf of dolomite and limestone rock jutting north-northeast into the Caribbean Sea (Lee, 1980; Wilson, 1980). The Yucatán Peninsula rises gradually to a maximum of 350 m along the western border with Campeche (Paynter, 1955a, 1955b; West, 1964). Bedrock deposition began in the Eocene age (50 million years ago) and resulted in limestone and dolomite layers that are several hundred meters thick (Bonet and Butterlin, 1962 [not seen, cited in Wilson, 1980]; López Ramos, 1973 [not seen, cited in Wilson, 1980]). Much of the surface limestone is thoroughly karsted; sinkholes and small caves are common.

Quintana Roo has three physiographic subdivisions (Wilson, 1980). The Cobá District, the northern half of the state, is a karsted plain with linear depressions, several large lakes, and an abundance of small hills and depressions. The Río Hondo District, the southern half of the state, is

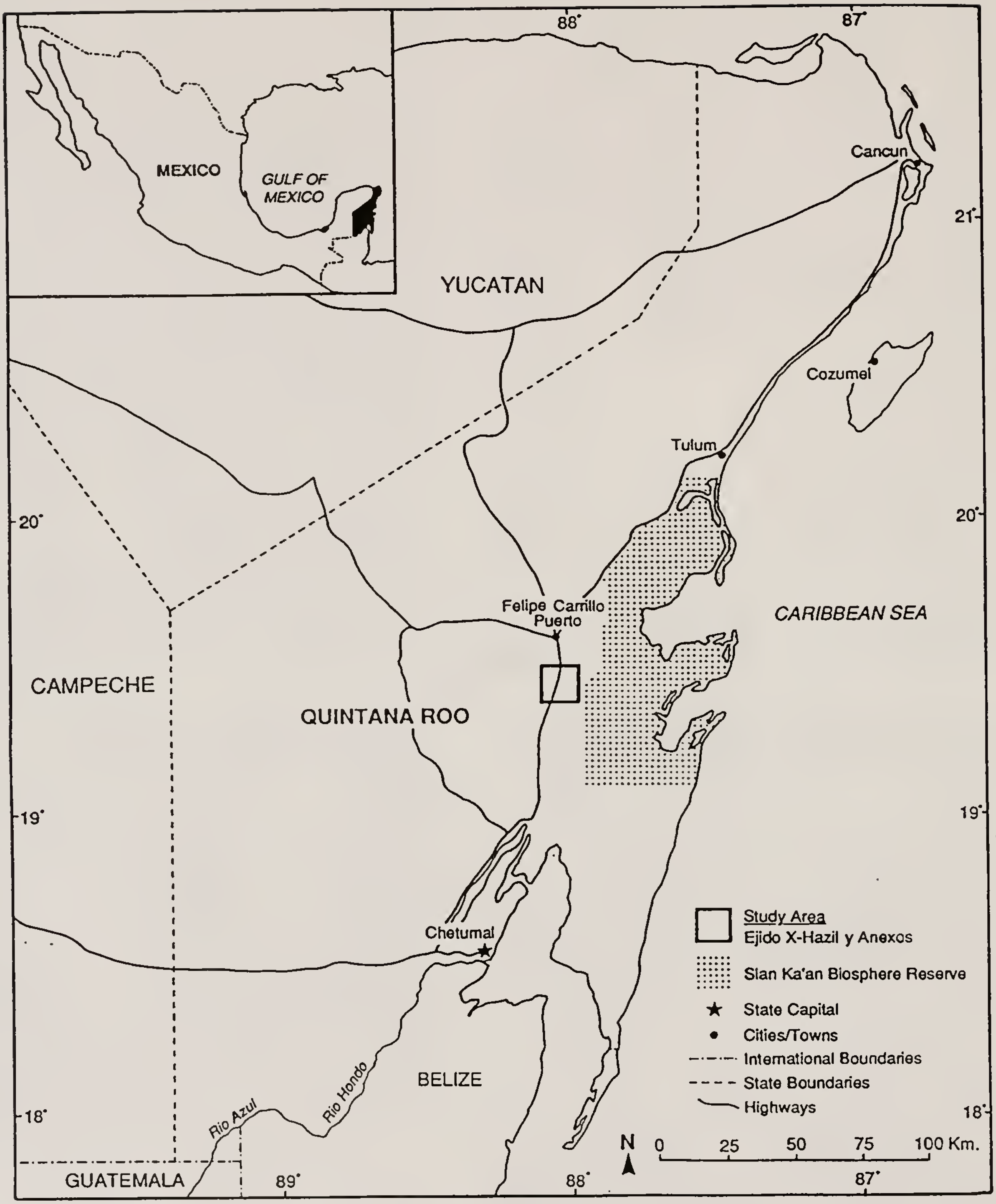

Figure 2-1. Location of Ejido X-Hazil y Anexos (study area), Quintana Roo, Mexico.

characterized by low relief and a number of linear fault depressions in which streams, lakes, and lake beds are located. This district also includes offshore islands of fault origin. The Río Bec District, encompassing a small portion of the state along the western boundary, is an area of intermittent lakes; broad, conical hills; and high linear ridges. The drainage patterns of this district are poorly developed.

Hydrology

Due to the low relief and limestone surface of Quintana Roo, rivers and lakes are rare, but the water table is high. Water frequently is found in wells today at depths of only a few meters (Wilson, 1980). In pre-Hispanic times, however, the Maya technology was insufficient for digging wells through the limestone so people often constructed cisterns to store water during the dry season (Killion et al., 1989). The Maya located their settlements near sinkholes that contained water during the entire year (Wilson, 1980).

Below the rock surface of the Yucatán Peninsula, a layer of freshwater overlies a layer of saline water (Back and Lesser, 1981). Movement of the freshwater is not via underground rivers, however, as is the case in Florida. Rather, due to hydrostatic pressure generated by rainfall, the freshwater moves along underground rock fractures from the interior of the Yucatán Peninsula to each coast. As a result, the underground freshwater is widely available rather than being found only in isolated areas.

The wide distribution of underground freshwater also has its drawbacks. Recently, geologists have questioned the wisdom of coastal developments for tourism or agriculture that might pierce the aquifer in the Yucatán Peninsula and allow freshwater and saline water to mix (Perry et al., 1989, 1990; Smart and Whitaker, 1990). Such mixing would be deleterious to wildlife, plants, and humans.

There are few sources of surface water in the state for either people or wildlife. The only river in Quintana Roo is the Río Hondo, which forms the border with Belize and drains into Chetumal Bay. There are about 34 shallow lakes in Quintana Roo (Escobar Nava, 1986). Sinkholes (*cenotes*) are widely distributed throughout the state and may measure up to 60 m in diameter (e.g., the "Sacred

Cenote at Chichén Itzá, State of Yucatán; Wilson, 1980), but diameters of 10 m are more common. Many species of small fish occur in the caves, lakes, and sinkholes (Barrera, 1964; Lipske, 1990). Shallow depressions (including natural collapse features called *aguadas* and small pothole features called *sartenejas* commonly occur on the surface. These depressions fill with water during the rainy season and retain water through much of the dry season, thus providing natural sources of water for wildlife, plants, and humans.

In response to the difficulties with obtaining drinking water from natural sources, the Maya of X-Hazil Sur now obtain their drinking water from personal wells near their homes as well as from underground pipes connected to the village water tank and supplied by a community well. These two sources are highly reliable, and water availability no longer is a problem, except during power outages or due to mechanical problems with the pumps. Water potability, however, is a separate issue as chemicals used to purify the water may not always be available or added as necessary to ensure water purity. As a results, village residents often suffered from diarrhea.

Climate

The climate of Quintana Roo is warm and humid. According to the Koppen terminology, the main climate category is Aw (Tropical Savanna; García, 1973). There are two, well-developed seasons; rainy and dry. The rainy season typically lasts from May through October (Sánchez Crispin, 1980; not seen, cited by Careaga Vilicsid, 1990). The driest two or three months typically have less than 60 mm precipitation each (Wilson, 1980). Annual precipitation in the state is 900-1,600 mm and mean temperature is 20-25°C. At the Sian Ka'an Biosphere Reserve (immediately to the east of the study site), annual precipitation is 1,000-1,200 mm, while about 70 percent of the rain occurs during May-October (Olmsted and Durán, 1991). The maximum temperatures occur during May-September, while the minimum temperatures occur during December-January. During the dry season, cold fronts (*nortes*) commonly move southward from the United States, causing thunderstorms, overcast skies, and substantially lower (ca. 10-20° change) temperatures (Wilson, 1980). These fluctuations, however, usually last only a few days at a time. Rainfall and temperature vary along a north-south gradient in the state, with more rainfall and lower temperatures in the south and less rainfall and higher temperatures in the north (Wilson, 1980; Escobar Nava, 1986).

Hurricanes frequently occur in the Caribbean Sea and strike the Yucatán Peninsula (Walker et al., 1991). The impact of these storms on the people, plants, and wildlife depends greatly on the force, duration, time of year, and the path the storm takes. During 1952-1978, 46 hurricanes traversed Quintana Roo (about two per year), including Janet (striking Chetumal in 1955) and Carmen (striking Chetumal in 1974; Escobar Nava, 1986).

Hurricane Gilbert, the last major hurricane to strike Quintana Roo, raged over the Yucatán Peninsula during 14-15 September 1988 and affected the human residents as well as the wildlife and associated habitats (Anonymous, 1988; Wilder, 1988). Between Cancún and Tulum Ruins, the rains, waves (about 6 m high), and winds (reaching 320 km/h) damaged roads, boats, buildings, beaches, power lines, and water pipes. Throughout the northern half of the state, lowlands were flooded, leaves were stripped from branches, and many trees were uprooted. This destruction was especially critical to Maya farmers throughout the region because their gardens were destroyed, but many species of wildlife that were crop predators also suffered due to the loss of crops.

Throughout the northern half of the Yucatán Peninsula, immediate as well as delayed impacts of Hurricane Gilbert became apparent. In the days following the storm, biologists in Cancún noted large numbers of dead and dying bats in the streets. They attributed this to the disappearance of insects, the bats' main food (J. Juárez G., pers. comm.). During the following dry season, in 1989, forest and grass fires raged across the Yucatán Peninsula and burned about 135,000 ha during four months (López-Portillo et al., 1990). The impact of Hurricane Gilbert on the local people, plants, and wildlife in Quintana Roo has yet to be quantified, but it is considered to be one of the most severe storms ever (Lynch, 1991; Whigham et al., 1991).

Soils

Soil physical and chemical properties directly affect the vegetation that can grow in an area. These properties indirectly affect people who plant gardens or harvest natural forest products, such as lumber. These properties also affect wildlife species that depend upon this vegetation for food and cover.

Unfortunately, the classification of soil types in Mexico is problematic, and a new classification scheme recognizing additional categories, especially in the Yucatán Peninsula, is being prepared (Dunning, 1989). Presently, the soils of Quintana Roo are classified as belonging to the order Rendzinas, suborder Calcomorfics, according to the FAO classification, while according to the USDA classification they are categorized as belonging to the order Mollisols, suborder Rendolls (U.S. Department of Agriculture, 1975). Rendzina soils are shallow; have low fertility levels; can be red or black in color; have good structure and drainage; and have a high content of calcium, carbonates, bicarbonates, and organic matter (Aguilera, 1959). Soil color can vary greatly between adjacent sites.

Soil physical and chemical changes in gardens in the X-Hazil Sur area are similar to those in other tropical sites subject to shifting cultivation (Noguez-Galvez, 1991). In general, after 20 years of fallow the physical and chemical values of the soil stabilize at levels similar to those of soils in late secondary forest. X-Hazil Sur residents, however, now practice a short fallow cycle, replanting about every 5 y, and increasingly complain about decreasing crop yields.

Noguez-Galvez (1991) conducted a study of soil characteristics in the same area as the present study, and reported the following selected soil chemical and physical properties of garden sites for 1 and 70 y of fallow at 0-5 cm of depth:

> Soil chemical properties: Organic matter (8.08% and 10.49%, 1 and 70 y, respectively), Total nitrogen (0.437% and 0.493%), PO_4 (12.16 ppm and 16.31 ppm), Ca^{++} (59.48 me/100g and 41.91 me/100g), Mg^{++} (3.58 me/100g and 3.42 me/100g), Na^{+} (1.04 me/100g and 0.96

me/100g), K^+ (3.11 me/100g and 2.37 me/100g), pH KCl (7.20 and 6.60), and pH H_2O (7.78 and 7.32).

Soil physical properties: Field capacity (52.39% and 57.23%), wilting point (21.59% and 22.55%), available water (30.77% and 33.54%), and bulk density (0.86 g/cm^3 and 0.76 g/cm^3).

These results suggested that the soils of the area can support horticulture, but that the present period of only a few years that Maya farmers leave the land to fallow will result in serious soil degradation. A fallow period of 20 y would allow soil physical and chemical properties to return to normal levels.

Below the soils of the Yucatán Peninsula there is hard surface limestone (Wilson, 1980). Widespread, especially in the north, this rock is formed by solution and precipitation of calcium carbonate near the ground surface. Plant roots break up the cemented grains and shell fragments into large chunks that litter the surface.

A material called *sascab* occurs below the hard surface layer (Wilson, 1980). Sascab is nearly pure calcium carbonate and forms as the surface limestone weathers. Friable, sascab is commonly mixed with cement by Mexican workers to make roads and building foundations.

Species Richness

Species richness is the number of species that occur in a specific geographical area without regard to their density or abundance. Among Mexican states, the species richness of Quintana Roo is relatively low, containing only about 20-30% as many species as the states with greatest richness (Flores-Villela and Gerez Fernández, 1989). About 151 species of vertebrates and 1,257 species of plants occur in Quintana Roo. Vertebrate endemism is low (five species), while plant endemism is estimated to be high. Species richness of Quintana Roo is enhanced by the fact that 79% of the natural habitat is categorized as unaltered and has not been significantly perturbed by recent human activity.

Flora

Several attempts have been made to characterize the vegetation of Quintana Roo. In describing and classifying the Yucatán Peninsula, Standley (1930), Lundell (1934, 1937), Leopold (1950), Paynter (1955a), Cabrera Cano et al. (1982), and Rzedowski (1986) generally recognized from three to six vegetation types. Tropical semi-evergreen forest is the dominant type in the Quintana Roo, occurring in the south and east, while tropical semi-deciduous forest is less dominant and occurs in the north and west (Rzedowski and Calderón de Rzedowski, 1989; Figure 2-1). Phytogeographically, the Yucatán Peninsula is more similar to northern Central America than to southern Mexico (Estrada-Loera, 1991).

The flora of central Quintana Roo is characterized by a medium-height forest that is 7-25 m tall (Cabrera Cano et al., 1982). The forest floor has both woody and herbaceous plants but little soil or organic matter. Lianas and epiphytes are abundant and are supported by a large number of trees. The dominant trees include the following; *Brosimum alicastrum*, *Bursera simaruba*, *Manilkara zapota*, *Metopium brownei*, *Psidium sartorianum*, and *Vitex gaumeri*.

The State of Quintana Roo has a long history of logging and shifting cultivation (Edwards, 1986). Although little information about deforestation rates is available for the state, Flores-Villela and Gerez Fernández (1989) determined that only 21% of the natural habitat had been significantly perturbed or was in the process of being transformed. Since 1957, commercial logging has been managed through cooperative agreements between the *ejidos* and the State Forestry Program (see Snook, 1993).

Fauna

Mexico is among the richest countries in the world in terms of the number of autochthonous animal species (Ramamoorthy et al., 1992). Within Mexico, however, the fauna of the Yucatán

Peninsula differs from other areas in that species endemism and diversity are lower than in the rest of the country. In addition, species distribution and abundance patterns for mammals and herps suggest that taxa in the northern part of the peninsula should be grouped into the Yucatán Biotic Province, while those in the southern part should be included with the Middle America taxa (Lee, 1980; Dowler and Engstrom, 1988).

Characteristics of Selected Mammals and Birds

Human cultural traditions and the distribution and abundance of animals determine which wildlife species are considered as game in an area and which are not. Mammals and birds were the main taxa of interest in this study. Excluding bats, insectivores, small rodents, marine mammals, and endemic species on offshore islands, there are about 40 species of mammals and 15 species of birds that are potential game taxa for Maya Indians in Quintana Roo (Chávez León, 1980, 1983; Gaumer, 1917; Leopold, 1972, 1977; Ramírez Pulido et al., 1982; Ramírez Pulido et al., 1983; Appendices A and B). The following summary is based on the literature, my personal observations, and information provided by Maya hunters.

Marsupials were not taken as game by mestizos or Maya hunters but were killed as they preyed upon chickens and ate pineapples (*Ananas comosus*) and other fruits in house gardens. These animals were viewed as pests (M. Cab Cohuo, pers. comm.).

Primates were not taken as game by Maya hunters in Quintana Roo, but in the past, adult females occasionally were killed so that their young could be sold as pets, especially spider monkeys (*Ateles geoffroyi*). Spider monkeys and howler monkeys (*Alouatta pigra*) are uncommon in the forests and rarely are taken by hunters (Navarro L. et al., 1990; Watts and Rico-Gray, 1987). These primates reportedly were much more abundant and widespread in the past (J. Poot Cruz, pers. comm.).

Edentates were not taken as game. Armadillo (*Dasypus novemcinctus*) meat, although regularly consumed by several other indigenous groups in the Neotropics (Redford and Robinson, 1987), was not consumed by the Maya because it contained muscle tumors. Hunters reported that their parents and grandparents frequently ate armadillo meat in the past as they knew how to remove the tumors (J. H. Balam Xiu, pers. comm.). Tamanduas (*Tamandua mexicana*) often were killed by motor vehicles at night along Mexico Route 307.

The single lagomorph species reported for western Quintana Roo was not present in the study area (Dowler and Engstrom, 1988; Jones et al., 1974b). Three of the six rodents were relatively common in horticultural areas and regularly were taken as game; paca (*Agouti paca*; ca. 8.2 kg), agouti (*Dasyprocta punctata*; ca. 3.6 kg), and pocket gopher (*Orthogeomys hispidus*; ca. 0.4 kg). The biology of these species in the Yucatán Peninsula is poorly known (Jones et al., 1974a).

Several species of carnivores occurred in the study area (Birney et al., 1974; Genoways and Jones, 1975). The coati (*Nasua nasua*; 3.8 kg) was an important game species as well as a troublesome crop predator. Coatis in large groups of up to 30-40 adult females and their young frequently entered gardens and caused extensive damage to the corn. Hunters reported taking pumas (*Felis concolor*) and jaguars (*Panthera onca*) for their skins, teeth, and meat. The ocelot (*Felis pardalis*) and margay (*F. wiedii*) also were taken for their skins. Only two hunters reported taking kinkajous (*Potos flavus*) and raccoons (*Procyon lotor*). Raccoons often were shot as they consumed corn seedlings, but the carcass usually was left by hunters to rot.

The tapir (*Tapirus bairdii*) was the largest mammal in the study area at about 275 kg, but hunters did not report taking this species. Hunters indicated that tapirs were hard to kill due to their thick skin and that the meat was not especially tasty. Tapirs occurred in the flooded lowlands in the eastern part of the study area, but were uncommon in Quintana Roo (Sánchez-Herrera et al., 1986).

There were two species of peccaries and two species of deer in the study area, and all four taxa of these ungulates were major game species (Birney et al., 1974; Genoways and Jones, 1975). Both species of peccaries occurred in groups that ranged widely over gardens and forested areas. The collared peccary (*Tayassu tajacu*; ca. 17.5 kg) was smaller, but more abundant than the white-lipped peccary (*T. pecari*; ca. 28.6 kg; Aranda Sánchez, 1981; March M., 1987). The brocket deer (*Mazama* *americana*; ca. 26.1 kg) and the white-tailed deer (*Odocoileus virginianus*; ca. 40.0 kg) frequently were observed in or around gardens.

The main game bird species taken by mestizos and Maya hunters at X-Hazil Sur include the tinamou (*Tinamus* spp. and *Crypturellus* spp.), great curassow (*Crax rubra*), plain chachalaca (*Ortalis vetula*), and ocellated turkey (*Agriocharis ocellata*; Griscom, 1926; Leopold, 1977; Chávez León, 1983; López Ornat, 1991; López Ornat et al., 1989; MacKinnon Vda. de Montes, 1989). Other species taken for meat, as pets, or because they are crop predators include the red-billed pigeon (*Columba flavirostris*), scaled pigeon (*C. speciosa*), parrots (*Amazona* spp.), and parakeets (*Aratinga* spp.).

The Maya of X-Hazil Sur, like other indigenous people in the Neotropics, take species of wildlife other than birds and mammals. For example, the Maya consume honey produced by wild and cultivated bees (Apidae; Chemas and Rico-Gray, 1991; Roubik et al., 1990). Honey is an important food item for several indigenous groups in the Neotropics (Posey, 1984; Posey and Camargo, 1985). The Maya also consume modest quantities of fish taken from local sinkholes during the dry season. About 30 species of freshwater fish have been reported from sinkholes in Quintana Roo, but only two species are important for subsistence purposes (*Rhamdia guatemalensis* [Pimelodidae] and *Astyanax fasciatus* (Characidae; Gamboa-Pérez, 1991; Wilkens, 1982 [not seen, cited in Gamboa-Pérez, 1991]). Fish also are widely consumed by indigenous groups in the Neotropics (Carneiro, 1970; Chernela, 1982, 1985).

The Maya of X-Hazil Sur, unlike many other indigenous groups in Mexico and throughout the Neotropics, do not consume insects or eggs or meat from snakes, terrestrial turtles, or lizards (*Ctenosaura similis*). This is in contrast to western Mexico, where lizard (*C. pectinata*) eggs and meat are consumed by local residents (Parra Lara, 1986; Santana et al., 1990). Maya hunters at X-Hazil Sur, however, recall that 10-20 years ago, along the east coast of Quintana Roo in what is now known as the Sian Ka'an Biosphere Reserve, Maya hunters harvested reptile products for commercial purposes. These hunters took hides from crocodiles (*Crocodylus moreleti*) and eggs and scutes from sea turtles (*Chelonia mydas*, *Eretmochelys imbricata*, and *Dermochelys coriacea*; J. Cab Can, G. Gómez Puc, and J. Poot Ake, pers. comm.). These wildlife products were sold to intermediaries and eventually were purchased by tourists or business people who fabricated articles made from these products.

Study Area

The study area was located on the Ejido X-Hazil y Anexos, one of the largest *ejidos* in Quintana Roo (Figure 2-1). The population of Ejido X-Hazil y Anexos during the study was about 1,680 people distributed in the three villages of X-Hazil Sur, Uh-May, and Chancah Veracruz (Dachary and Arnaiz Burne, 1989; Dr. Juan Chi, pers. comm.). *Ejido* residents were primarily Maya and lived in the villages, except for about 10 people who lived on a semipermanent basis at farms or camps (*ranchos* and *campamentos*) in the forest. The *ejido* is composed of the direct descendants of the Maya who fought Mexican soldiers for more than 50 y during the Caste War (Reed, 1964; see below). While Dachary and Arnaiz Burne (1989) suggested that the population of the *ejido* had declined, local officials (D. Ake Ayala, pers. comm.) indicated that the *ejido* was growing in population. At about 3.0 persons/km^2, the human population density on the *ejido* was greater than the density on many other nearby *ejidos*. For example, Ejido X-Maben had a density of only 0.8 persons/km^2 (Murphy, 1990).

The three villages that compose the *ejidos* were founded about 1915 after a smallpox epidemic. Deaths due to this epidemic occurred throughout the region as well and forced many residents to abandon their homes to seek new places to live (Villa Rojas, 1987:149). The presence of a few small stone structures on the *ejido* suggests that the area was populated by the early Maya, but these structures have not been studied by archeologists. Local residents suggested, however, that the area had a relatively recent occupation dating from the early 1900s when four or five families founded a small village near the site of Rancho Las Palmas (Kilometer 95, Route 307; and S. Yeh Ake, pers. comm.). These same families eventually founded the *ejido*.

Due to the large size of the *ejido* (55,295 ha) it was decided to focus the study on the community of X-Hazil Sur (19°23'30"N, 88°05'00"W), the largest of the three villages. In 1992 the population of X-Hazil Sur was 1,040 (Dr. Norbierto Ramírez Morales, in litt.; 539 men and 501 women; Figure 2-2). About 52% of the men and 47% of the women were between the ages of 15 and 59, while only about 5% of the total population was ≥ 60 years old. During 1989-1992 the population of X-Hazil Sur grew from 950 to 1,040, but this reflected emigration and immigration, as well as births and deaths.

Temperature and precipitation were measured at X-Hazil Sur during July 1989-December 1990 (Figure 2-3; Appendix C). The highest temperature recorded was 39°C on 28 and 29 May

Figure 2-2. Distribution of X-Hazil Sur residents by age class and sex. There were 539 males and 501 females during the census of 1992.

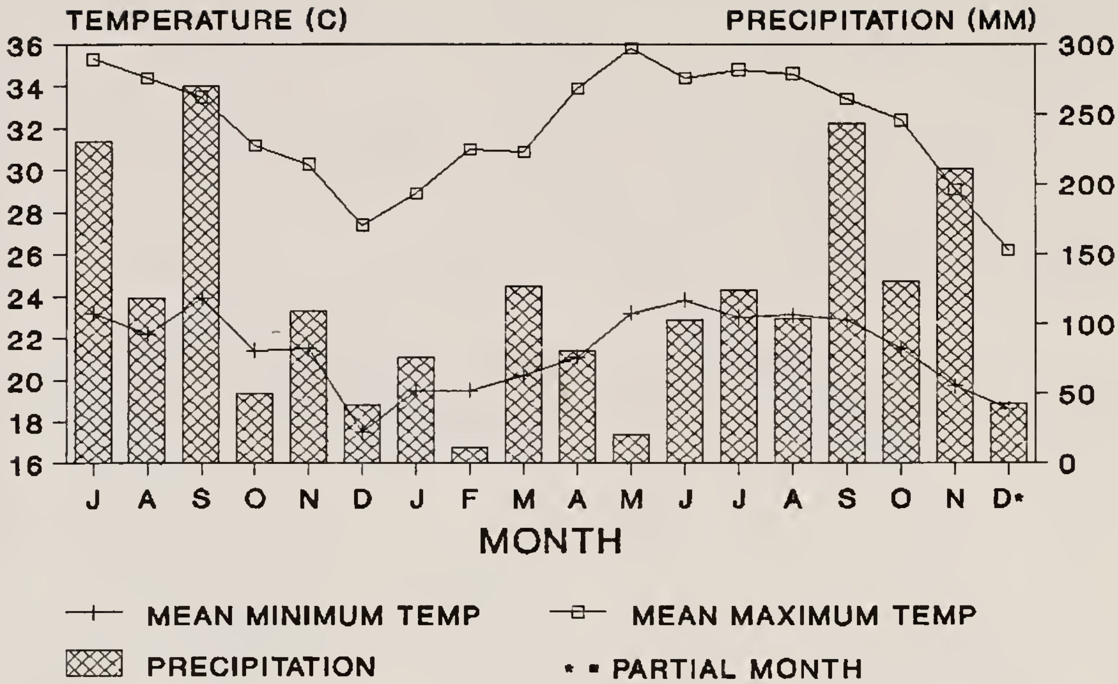

Figure 2-3. Mean monthly temperature and precipitation at X-Hazil Sur, Quintana Roo, Mexico, during July 1989-December 1990.

1990, while the lowest temperature recorded was 9°C on 27 December 1989 (temperature was measured by a thermometer ±1C° and read daily at 0700 h to obtain the minimum and maximum temperatures for the preceding 24 h). Rainfall during 1 January-12 December 1990 was 1,277.3 mm, slightly above average (rainfall was measured by a rain gauge and read daily at 0700 h). Local residents reported that during the past several years it had been drier than normal and that the rainy season had begun 1-2 months later than normal.

The *ejido* was composed of four major land-use and vegetation types: Plots & Gardens (6.07% of *ejido*), Early Secondary Forest (5.18%), Late Secondary Forest (88.52%), and Other (0.23%; Table 2-1). Sites categorized as Plots & Gardens mainly were located near the three villages or along roads, while sites categorized as forests usually were located relatively far from the roads (Figure 2-4). The *ejido* was accessible through many types of thoroughfares. These roads and trails greatly influenced subsistence and economic activities in the *ejido*. The main road was Mexico Route 307, a hard surface

Table 2-1. Land uses and vegetation types at Ejido X-Hazil y Anexos, Quintana Roo, Mexico.[a]

Land uses and vegetation types	Area (km^2)	% Total
Plots & Gardens	33.56	
Subtotal	33.56	6.07
Early Secondary Forest		
Former gardens	26.44	
Cattle corrals & pastures	2.18	
Subtotal	28.62	5.18
Late Secondary Forest & Low Moist Forest		
Medium height, semi-evergreen forest	418.74	
Low height, semi-evergreen forest	63.18	
Seasonal wetlands	7.21	
Ponds & Sinkholes	0.35	
Subtotal	489.48	88.52
Other[b]	1.29	
Subtotal	1.29	0.23
Total	552.95	100.00

[a] The area was determined by using a compensating polar planimeter to measure land uses and vegetation types on a 1987 map (1:25,000 scale) produced by the Plan Estatal Forestal. The map was based on aerial photographs (Instituto Nacional de Estadística Geográfica e Informática, February 1985, 1:37,000 scale), topographic maps (Instituto Nacional de Estadística Geográfica e Informática, 1987, 1:50,000 scale).

[b] The category "Other" was composed of village sites and previously forested areas (*rodales*) where logs were sorted, trimmed, and loaded.

road that extended from north to south. Secondary roads connected X-Hazil Sur and Chancah Veracruz to Route 307. Most gardens were located within about 2 km of these roads. The *ejido* was further

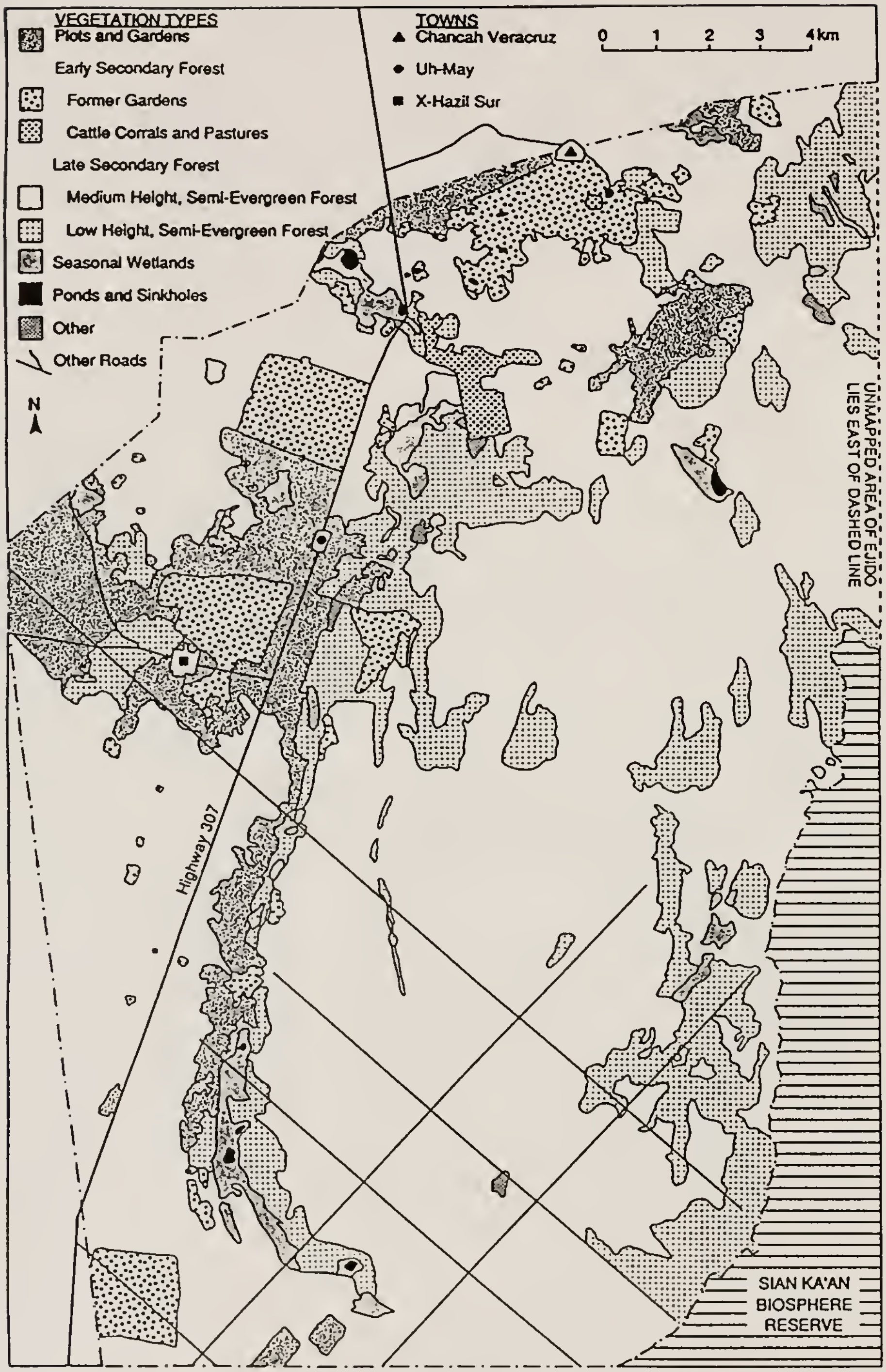

Figure 2-4. Land uses and vegetation types at Ejido X-Hazil y Anexos.

subdivided by oil exploration roads that were constructed by Pemex about 1980-1982 (D. Ake Ayala, pers. comm.). The Pemex roads greatly facilitated travel in the eastern part of the *ejido*, especially to logging and chicle tapping sites. Paths, trails, logging roads, and old horse trails between villages and camps also penetrated the area and frequently were followed by hunters. In summary, probably no part of the *ejido* was more than 4-5 km from a trail or road.

Forest Successional Stages

Barrera de Jorgenson (1993) surveyed the trees at Ejido X-Hazil y Anexos and compared the population structure and tree species diversity for areas categorized as Late Secondary Forest versus Early Secondary Forest. In Late Secondary Forest, a total of 98 species from 33 families were recorded ($\underline{n}$ = 2850 trees ≥ 2 cm dbh). The most abundant species in Late Secondary Forest were false lignum vitae (*Gymnanthes lucida*, $\underline{n}$ = 392 trees, dbh range = 2-31 cm, $\bar{x}$ dbh = 8.6 cm), *chac ya* (*Nectandra coreacea*, $\underline{n}$ = 244, dbh range = 2-47 cm, $\bar{x}$ dbh = 10.04 cm), and sapodilla (*Manilkara zapota*, $\underline{n}$ = 171, dbh range = 2-83 cm, $\bar{x}$ dbh = 19.73 cm). In Early Secondary Forest, a total of 60 species from 26 families were recorded ($\underline{n}$ = 808 trees ≥ 2 cm dbh). The most abundant species in Early Secondary Forest were *nees* (*Gymnanthes lucida*, $\underline{n}$ = 94 trees, dbh range = 2-10 cm, $\bar{x}$ dbh = 5.3 cm), wild grape (*Coccoloba cozumenlensis*, $\underline{n}$ = 59, dbh range = 2-5 cm, $\bar{x}$ dbh = 5.11 cm), and white gombolimbo (*Dendropanax arboreus*, $\underline{n}$ = 55, dbh range = 2-16 cm, $\bar{x}$ dbh = 4.95 cm).

Cultural and Socioeconomic Environments

The Maya of X-Hazil Sur are a highly acculturated people, having changed much over the past two-three generations, but they maintain many traditional customs. For example, most residents of this village speak Spanish in addition to Maya, wear Western clothing, own a radio or television, and regularly travel by bicycle or motor vehicle to adjacent towns and villages. However, many of these same individuals also observe special rituals as they butcher game, construct rudimentary dwellings, and plant and harvest their gardens. They also believe in spirits (e.g., San Juan and San Miguel), and commemorate their dead, as they have done for hundreds of years. While some of these practices may appear to follow the Catholic religion, they have their basis in traditional Maya beliefs. The result is that the current cultural environment is a hybrid of traditional and modern beliefs (Careaga Viliesid, 1990).

Information about Maya Indians and the Yucatán Peninsula has been compiled since the early 1500s. Among the first European visitors who published descriptions about the area were priests, explorers, and government officials (cf., Cook, 1769 [cited in Villa Rojas, 1987]; Dávila, 1870 [cited in Villa Rojas, 1987]; Landa, 1978; Stephens, 1963, 1969). While these authors were amazed by the size and complexity of the large ceremonial centers encountered throughout the region, they considered the local Maya residents to be backward and ignorant. With respect to the area itself, these writers described the Yucatán Peninsula as an extremely harsh environment.

Accounts about Maya culture published since the early 1900s have described a sophisticated society. Linguists and chroniclers, for example, have documented the important role that Maya cosmology has in Maya oral history and daily conversations, including those between Maya and foreigners (Burns, 1973, 1977, 1980, 1983; Hanks, 1990; Sullivan, 1987, 1989). For example, a series of stories may include references to animal spirits, the creation of the world, and an epoch of miracles when half a kernel of corn was sufficient to make tortilla dough for a meal for 6 or 8 people. The conversation then could switch to comments about the Queen of England, accounts of slavery in the United States, and analyses of recent world wars. From these accounts it is clear that Maya oral histories and conversations contain a rich mixture of references to past, present, and future events. History and cosmology also mix references to actual peoples with those to spirits and deities.

Archeologists also have documented the complexity of Maya subsistence practices, settlement patterns, and the chronology of large ceremonial centers (Andrews, 1942, 1960, 1965, 1973; Lizardi

Ramos, 1939 [cited in Villa Rojas, 1987]; Lothrop, 1924; Pollock, 1940). Recent archeological studies, however, have challenged traditional views of a cultural elite supported by simple farmers and concluded that the Maya had well-populated cities supported in part by intensive horticulture (Sabloff, 1991).

Anthropologists have described the dynamic nature of Maya daily life. Maya grammars and ethnographies, for example, have described a culturally rich people with a written language and extensive knowledge of useful plants and animals around their villages (Gann, 1918, 1926, 1935; Morley, 1927, 1938, 1956; Redfield and Villa Rojas, 1962; Steggerda, 1941; Thompson, 1930; Tozzer, 1907, 1921; Villa Rojas, 1969, 1987). In addition, the Maya have adapted traditional horticultural practices to new environmental conditions as they occupy new areas (e.g., Guatemala; Carter, 1969). Studies also have shown that Maya women are taking a more active role in the political and economic aspects of daily life (Elmendorf, 1976). These examples clearly show that the vibrant nature of contemporary, Maya daily life.

In spite of the numerous accounts over the past 150 years, research results published during the past 5 years are forcing investigators to rethink many of their ideas about the historical Maya described from archeological sites. The traditional image of Maya culture, as indicated above, is a series of elaborate ceremonial centers with a peaceful, ruling elite supported by a peasant class practicing hunting, gathering, and shifting cultivation. New interpretations of hieroglyphic inscriptions suggest that the Maya engaged in extensive armed conflict (Marcus, 1991; Schele, 1991). Other studies have confirmed the presence of complex cities, intensive horticulture, and sophisticated religious symbolism (Hansen, 1991; Rice, 1991; Tolstoy, 1991). This has lead to an expanded view of the historical Maya culture that now appreciates the role and activities of the elite, as well as the nonelite, in daily life and recognizes that the historical Maya were able to manipulate their environment in order to sustain intensive horticulture and avoid environmental degradation (Andrews, 1991; Harlow, 1991; Sabloff, 1991; Turner, 1991).

Historical Setting

There is some debate about when people first inhabitated Mesoamerica. While some would argue that the earliest settlers in Mesoamerica arrived about 25,000 B.C. (Adams, 1991), others scientists would contend that about 7,000 B.C. is more probable (Nesbitt, 1980). The Maya Indian civilization developed during 1500 B.C.- 150 A.D. (Formative Period). By about 800 B.C., the Maya had founded the city of Dzibilchaltún, near Mérida, and several other smaller villages along the coasts of the Yucatán Peninsula and south to Belize, Guatemala, Honduras, and El Salvador (Andrews, 1960, 1965; Deevey et al., 1979).

During 150/300-650/900 A.D. (Classic Period), the Maya increased in number and developed an advanced culture that included a calendar, number system, network of roads, written and spoken language, trade routes that reached from central Mexico to Panama, and a system of horticulture that used raised gardens irrigated by canals (Denevan, 1970; Flannery, 1982; Pohl, 1985; Sabloff, 1991; Turner and Harrison, 1983). At the height of their power during 1250-1519 A.D. (Late Postclassic Period), the Maya in the northern part of the Yucatán Peninsula numbered about 800,000 inhabitants (Clendinnen, 1987; Cook and Borah, 1974).

Perhaps the Maya are best known for their large ceremonial centers, including Tikal (Guatemala), Cobá and Tulum (Quintana Roo, Mexico), and Uxmal and Chichén-Itzá (Yucatán, Mexico; Lothrop, 1924; Stephens, 1963; Thompson, 1966; Thompson et al., 1932, 1940). During 650/900-1250 A.D., for reasons that still are being debated, the Maya civilization declined in size and power (cf., Adams, 1977, 1991; Cowgill, 1962; Culbert and Rice, 1990; Morley, 1956; Thompson, 1966; Willey and Shimkin, 1973).

In 1511, the Maya were first contacted by Europeans—albeit accidentally—when some Spanish sailors were shipwrecked at a site called Las Viboras along the northern coast of the Yucatán Peninsula (Landa, 1978). Several skirmishes ensued in the following years as other Spanish sailors attempted to rescue their comrades and explore the coast. In 1527, the Spanish, who were searching for slaves and wealth, began their conquest of the Yucatán Peninsula, and by 1542 had founded the city of Mérida.

During the following 300 years, the Spanish expanded their power along the northern coast, but various Maya chiefs retained control in the interior of the Yucatán Peninsula (Reed, 1964; Villa Rojas, 1987).

Due to harsh treatment of the Maya as the Spanish expanded their power and presence in the Yucatán Peninsula, relations between the two groups were poor, and in 1847 the Maya began a rebellion, subsequently called "The War of the Castes" (Reed, 1964). The severest fighting lasted from 1847 to 1855, during which about 57,000 people perished (about 17% of the total population of the Yucatán Peninsula; Cook and Borah, 1974). Maya farmers armed with guns and machetes eventually held 80% of the Yucatán Peninsula and almost took Mérida, by that time the prosperous Spanish capital of the Yucatán; but these men stopped fighting "temporarily" in order to return to their homes and plant their gardens (Reed, 1964). This decision by the Maya to postpone fighting was a major error and allowed the Spanish to regroup. Eventually the Spanish prevailed, but isolated cases of resistance by the Maya, primarily in the area of Felipe Carrillo Puerto (Quintana Roo), continued until the early 1900s (Escobar Nava, 1986; Reed, 1964; Sullivan, 1989).

Quintana Roo was declared a territory of Mexico in 1902 and state in 1974 (Escobar Nava, 1986). According to a 1902 estimate, the population of the Quintana Roo was about 5,000 people (Dachary and Arnaiz Burne, 1983). By 1970, just prior to the modern period of growth and development, the population of Quintana Roo was 88,150 inhabitants, with about 55.4% of the population born in-state (mostly Maya Indians) and 43.4% born out-of-state (mostly mestizos; Dachary and Arnaiz Burne, 1984). Largely ignored by the Government of Mexico until the mid 1950s, the Maya and mestizos of the state subsisted mainly by hunting, gardening, extracting lumber from the forest, and harvesting chicle latex from sapodilla (*Manilkara zapota*) trees.

The cultural and physical isolation experienced by residents of Quintana Roo lessened in 1955, after Hurricane Janet struck the Yucatán Peninsula and caused major damage to the Chetumal area in southern Quintana Roo. After receiving the damage reports, government officials and private citizens from throughout Mexico became aware of the poor social and economic conditions of the state.

Eventually several social and economic programs, including the construction of roads, schools, and hospitals, were undertaken to improve the quality of life in Quintana Roo (Escobar Nava, 1986).

By 1983, the population of Quintana Roo had increased to 330,813 inhabitants and reflected much recent growth and development in the state. Chetumal (75,113 inhabitants), in the southern part of the state, has prospered as the state capital and as a thriving commercial center for trade with Belize. In the north, the cities of Cancún (about 81,000 inhabitants) and Cozumel (23,224 inhabitants) have flourished since the mid 1970s as resorts for national and international tourists (Dachary and Arnaiz Burne, 1984). Today, less than 40% of the population of Quintana Roo lives in rural areas, in administrative units called *ejidos* (described below), and still practices traditional subsistence activities (Dachary and Arnaiz Burne, 1984).

Ejido System in Mexico

The village of X-Hazil Sur is a part of Ejido X-Hazil y Anexos and is located about 25 km S of Felipe Carrillo Puerto (Figure 2-1). The *ejido* system was instituted in Quintana Roo in 1928 to allow Maya Indians and other rural people to have title to specific tracts of land around their villages in areas that previously were considered government lands. These tracts were held in communal ownership where the residents could live and practice their subsistence activities. Previously, government officials sold concessions on these lands to outside business people without compensating local residents; a great deal of resentment among local residents resulted. The objective of the new system was to improve relations between business people, local residents, and government officials by giving local people control over their lands.

Ejidos are properties, either owned by the government or expropriated from private owners, where landless *campesinos* (subsistence farmers) have usufruct to the area (Gordillo, 1988). In this system, the residents do not have title to individual plots of land within the *ejido*; rather, they enjoy control over a plot as long as they live on it or continue to work it. Certified residents are called *ejidatarios* (adult men who are certified legal residents of the area and widows voting on behalf of their deceased husbands). If an *ejidatario* ceases to live on a plot or to work it, other residents are free to use that site without obtaining permission from any local official or the previous user.

The creation of *ejidos* resulted in a mechanism that allows residents to manage their timber resources and distribute among themselves the profits from any contracts with outside business people. While timber contracts are based on tree inventories conducted by government foresters and approved by the Ministry of Agriculture (Secretaría de Agricultura y Recursos Hidraúlicos, SARH), *ejido* residents conduct tree replanting programs and are free to negotiate prices with potential buyers (M. Carreón Mundo, pers. comm.).

Ejido X-Hazil y Anexos is governed by three officials; mayor (*comisariado*), secretary/treasurer (*secretario*), and enforcement officer (*inspector*). These officials handle the formal affairs of the *ejido* and are selected by villagers at elections every 5 years. None of these officials can be re-elected. An additional official, the village delegate (*sub-delegado*), handles local legal matters (e.g., the issuance of birth and death certificates) and is selected by state government officials located in the town of Felipe Carrillo Puerto. Other local individuals supervise work projects on the *ejido*, such as the collection of chicle and the extraction of timber. These officials also are elected by *ejidatarios* and an effort is made to rotate these positions among qualified candidates as the coordinators organize work crews, oversee projects, and receive a small salary.

An important aspect of the *ejido* system is that nonresidents are not allowed to exploit *ejido* resources, such as timber or game, without the permission of *ejido* residents. Permission depends upon a majority decision and is rarely given. In this way *ejido* residents maintain control over their local resources.

Ejido X-Hazil y Anexos was created by a decree from the state governor in 1941 and enlarged by presidential decree in 1942 (Dachary and Arnaiz Burne, 1983). Over the years, areas have been added or removed from the *ejido* to accommodate the formation of new *ejidos*. The present size of the *ejido* is 55,295 ha (Dachary and Arnaiz Burne, 1989).

Ejido members must be Maya in order to be *ejidatarios*. Previously *ejido* membership at X-Hazil y Anexos was granted automatically to all young men (about 16-18 years old) upon application to the *comisariado* and after fulfilling the requirements of planting a garden, maintaining a residence at the *ejido*, and collaborating on community work projects (*faenas*). These members then shared in the profits of timber sales by the *ejido*. Presently, the *ejido* has about 400 members. New members no longer are being accepted because current *ejidatarios* voted to restrict membership after per capita profit shares became unacceptably small. Today, as young men come of age, they still may live and work on the *ejido* but cannot share in any distribution of timber sale profits.

Social Organization

The social organization of indigenous groups is affected by many factors. One important factor is the ability to obtain food for personal consumption (Harris, 1974). Many indigenous people also share or exchange game for social and nutritional reasons (Stearman, 1989). In some cases, these exchanges extend to all group or village members, while in other instances, the sharing is limited to the immediate family of the hunter. Maya hunters are known to share or exchange game, but the importance of game to Maya social organization has not been studied.

Maya households at X-Hazil Sur today vary in size and composition. Nuclear family households (husband, wife, and children) are the most common type, composing about 75% of the households, and are similar to those described by Redfield and Villa Rojas (1962), Webber (1980), and Villa Rojas (1987). Multiple family households (each family a separate economic unit; e.g., an adult man and his immediate family living adjacent to his parents with father and adult son working together, but dividing the crops) and extended domestic families (more than one family constituting a single economic and social unit; e.g., an adult man and his immediate family living adjacent to his parents with father and adult son working together, and sharing the crops) also are common. The typical household at X-Hazil Sur is composed of 8-10 people. Household size and composition may vary over time as children become independent and elderly adults become dependent as they no longer can care for themselves. The size and composition of Maya households is important as members engage in the various subsistence activities necessary for survival. Family members, regardless of age or where they live at X-Hazil Sur, frequently share game and exchange food on special ceremonial days, but are not bound by tradition to share with nonfamily members.

The close ties between family members affected the layout of the village through the location of houses. In X-Hazil Sur, family groups frequently formed neighborhoods composed of adjacent, but completely separate *solares* and houses that contained the grandparents, parents, and adult children. This close physical proximity of houses to each other facilitated inter-family closeness, but also increased friction between relatives during family feuds.

Given the cultural traditions of the Maya, with the family and kinship being highly important, and the great difficulties associated with subsisting in Quintana Roo, it is not unusual for there to be few unmarried adults or abandoned children at X-Hazil Sur. During 1989-1990, there were several single adult men (primarily young men or widowers), while there was only one adult woman (about 25 years old) who was single and unmarried by choice. There were, however, several adult men and women who previously had been married, but subsequently had separated or divorced. Some of these adults continued to live alone in their houses (usually the men), while others returned to the household of their parents (usually the women). In households where a divorce, remarriage, or death of a parent had occurred, the children often were sent to live with their aunts or uncles, but never abandoned. Some widows and widowers continued to live with their children, while others returned to live with their parents or other family members. Divorced adults frequently found new partners. Thus, by being flexible, both children and adults were able to obtain support from friends or relatives.

As young adults mature at X-Hazil Sur, they may continue to live with their parents or leave and establish new households. Unmarried adults usually remain with their parents. After getting married, an adult male frequently builds a new house for himself. This house generally is located in a lot near the house belonging to his parents or other male relatives, such as an uncle or brother. Young men usually marry at about 20 years of age. Men traditionally seek younger spouses in the same village. A young man, recently married, typically will hunt and work with his father, father-in-law, or other adult male relatives for 1-2 years until he accumulates enough resources and experience to become economically independent.

Maya men and women at X-Hazil Sur and throughout Quintana Roo have separate roles in the household. Men hunt, plant gardens, harvest chicle, extract lumber, provide firewood, maintain the house and yard, and care for goats and cattle in outlying corrals. Women attend to the house and the children, tend house gardens (cf., Forrest, 1991), and raise and sell domestic animals (e.g., pigs, turkeys, and chickens) in order to supplement family income. Some of these products are sold locally, while others are sold in the town market at Felipe Carrillo Puerto.

Maya children at X-Hazil Sur often assist their parents with household chores. A young boy may accompany his father to the garden, but will do little manual work (e.g., planting, weeding, or harvesting) until he attains 10-15 years of age. Young boys, however, often are sent on minor errands, for example, to find firewood or to scare animals from the gardens. Boys usually don't begin hunting until about 15 years of age.

Young Maya girls, on the other hand, experience a vastly different childhood than boys do. From the time she is about 5 years old, a young Maya girl assists her mother by helping in the kitchen, caring for younger siblings, and by bringing corn to a local store to be ground into meal. Girls don't hunt or clean game, but are expected to cook the meat and prepare tortillas after the men return. By about the age of 15 years, most Maya girls have learned their adult roles and are able to manage a house and care for a family, while most boys are just beginning to learn their corresponding roles.

Social structure in Maya communities is Yucatán has been a difficult subject among anthropologists. While clear economic differences exist among individuals and families, these have not resulted in structured hierarchies of social classes. Redfield (1960) notes that the ideology of Yucatec Maya villages promotes egalitarian relationships. At the same time, the history of the 19th century Caste War in the area (Burns, 1977) suggests that social stratification along patrilineal family lines was an important feature of Maya political organization (Jones, 1977). One thing many authors have noticed, however, is the pervasive importance of factions in village life (Re Cruz, 1992; Redfield, 1960).

In short, village social structure in Quintana Roo sometimes appears to anthropologists as a classic case of a closed corporate peasant community (Wolf, 1957) where distinctions of wealth and status are downplayed. At other times, remnants of the Caste War political leadership system are used to structure social relations. Finally, factions and schisms rise and fall in villages, resulting in the appearance of economic stratification that might be just an accident of recent history.

The Maya of Quintana Roo are not just Mexican peasants, as Foster (1967) and others describe. But neither are they pristine tribal peoples. They are villagers who have developed systems of social relations that exhibit community differentiation, but are not mirrors of Western social classes.

The social hierarchy or stratification at X-Hazil Sur can be seen in men who occupy the major administrative positions and some families that tend to be more prosperous than other families. At X-Hazil Sur and throughout the Yucatán Peninsula, village officials are elected, usually for single terms of office, by *ejidatarios*. Single adult women at X-Hazil Sur are proscribed by community vote from independent or separate economic activities, such as operating a restaurant or having an individual lot for a house or garden in Ejido X-Hazil y Anexos.

Although Maya villagers do not have a social hierarchy or stratification that mirrors western social classes, there are local individuals who perform special functions. For example, shamans cure illnesses, midwives deliver babies, and religious officials oversee spiritual matters. These people have undergone an apprenticeship locally and continue to serve as long as their services are requested by village residents. There are no shamans in the village of X-Hazil Sur, but there are several midwives (*parteras*), one male herbalist (*yerbatero* or *curandero*), and two men and one young woman who pray at religious ceremonies (*rezador*). These positions sometimes pass from parent to child after the appropriate training. Several other men direct specific activities at the church, and usually are assisted by their wives. The motivation for undertaking these activities vary. Some men indicated that it was their way of giving thanks to the Maya gods for curing an ill child or granting a bountiful harvest from the garden. Other men indicated that it was a way to placate the Maya gods and avoid potential misfortunes. While these actions superficially resemble the practices of *cargos* (burdens) or *promesas* (promises) reported for highland peasant communities (Dumond, 1977), the Maya do not accrue prestige by these activities (Burns, pers. comm.). In adjacent villages, herbalists (both male and female) also treat various illnesses. While these people are treated with respect by village residents and receive a small compensation for their services, they are not afforded permanent or formal recognition and do not accrue prestige or political power over time.

Primary school attendance is mandatory in Mexico. Students at X-Hazil Sur can attend grades K-8 locally. Secondary school attendance is voluntary. Students willing to pay tuition may attend school in Felipe Carrillo Puerto, about 30 minutes away by bus. In an effort by *ejido* residents to reduce the costs of attending secondary school, in 1990 a secondary school was opened at X-Hazil Sur where instruction takes place via television (*telesecundaria*).

X-Hazil Sur residents also may attend post-secondary classes in nearby towns. Technical courses, such as accounting and hotel management, frequently are taught in Cancún, Chetumal, and Felipe Carrillo Puerto through various government programs. Increasingly, young adults are completing their education and obtaining jobs outside of X-Hazil Sur.

Settlement Patterns

Maya Indians in Quintana Roo presently live in a wide variety of villages, towns, and cities throughout the state. Most of the villages, such as X-Hazil Sur, have little commercial activity and are inhabited almost solely by Maya people. Since X-Hazil Sur is larger than other nearby villages, it also has a school, medical clinic, and satellite television system. Village stores are linked to those in towns by traveling salesmen who represent specific product lines, such as soda pop, bicycle parts, and groceries. The variety of merchandise, however, is limited. Towns, such as Felipe Carrillo Puerto, are larger than villages and have local government offices, important commercial activity, and are inhabited by both Maya and mestizos. Cities, such as Chetumal and Cancún, are the largest population centers in the state and have Maya, mestizos, and large numbers of national and international tourists. Most of the Maya in Quintana Roo live in villages, however.

According to the 1983 census, there were 2,792 population centers in Quintana Roo, with 90% containing fewer than 50 people each (Dachary and Arnaiz Burne, 1984). The 11 largest population centers (≥ 2,500 residents) have a combined population of 214,935 inhabitants (65% of the total population).

Maya at X-Hazil Sur live in two basic styles of houses. The traditional house is composed of poles and thatch, measures about 4 by 6 m, and is rounded on each end (cf., Redfield and Villa Rojas [1962], Webber [1980], and Villa Rojas [1987]). About 70-80% of the houses at X-Hazil Sur are of this type. Almost all houses have electricity (usually one outlet and one 60 watt bulb per house) and running water (usually one faucet located outside, near the front door of the house). Traditional houses may have either a dirt or cement floor, while the walls may be of poles or plaster, and the roof may be of tar paper or palm fronds (including *Sabal yapa* and *Thrinax radiata*). The modern house is of masonry, has windows, is rectangular in shape, and usually has a cement roof. The masonry house usually is less comfortable than the wooden house because air circulation is limited and the roof and walls tend to radiate heat after sunset. Only a few of the masonry houses have modern conveniences such as indoor plumbing or a kitchen with stove and running water within the house. Modern and traditional houses are laid out in a grid pattern, about 50-100 m on a side, and 4-6 families usually occupy a 1 ha block. Many households consisting of several nuclear or extended families have both types of houses.

Subsistence and Economic Activities

The Maya at X-Hazil Sur conduct numerous kinds of subsistence and economic activities. The main subsistence activity is to clear forested areas and plant a garden containing corn (*Zea mays*; Ho loch in Maya), beans (*Phaseolus* spp.; Buul in Maya), squash (*Cucurbita* spp.; Kuum in Maya), and numerous other crops (Dachary and Arnaiz Burne, 1983; Redfield and Villa Rojas, 1962; Villa Rojas, 1987; Webber, 1980). An important aspect of this practice is that most trees survive the clearing process and readily resprout (Rewald, 1989). This ability to resprout helps to facilitate the recovery of the forest after the garden is placed into fallow.

Gardens typically are about 2 ha in size, located near the village, and are tended by adult men (see Chapter 6 for additional information about gardens). Women rarely assist the men in tending the garden, but young boys frequently begin to help when about 10-15 years old. Gardens usually produce a single harvest of corn in December-January, but other crops may continue to produce for 1-2 years (e.g., *camote* [*Ipomoea batatas*; Is in Maya] and *macal* [*Dioscorea* sp.; Macal in Maya]). Men occasionally work for wages ($4-5/day) on a temporary basis, tending gardens or building houses locally.

While tending a garden is not a daily, full-time task at X-Hazil Sur, the work requires careful planning and must be conducted in a sequence that closely conforms to the weather (Noguez-Galvez, 1991). The men clear (*la tumba*) the garden site during January-March and take advantage of the bright sun during April-May to dry out the bushes, ground litter, and felled trees. Just before the rainy season begins, in May or June, the men set fire to the site in a carefully controlled burn (*la quema*) that lasts 1-2 h. The men plant (*la siembra*) in May-July (depending upon when the rainy season begins) and weed (*el chapeo*) the garden one or two times during August-October. During October-November, the men double or bend over (*doblar*) the corn stalks to facilitate drying and avoid predation by birds and coatis. The corn harvest (*la cosecha*) occurs during December-January. Other crops are planted and harvested throughout the year.

Maya women also engage in subsistence activities (Elmendorf, 1976; Redfield and Villa Rojas, 1962; Villa Rojas, 1987; Webber, 1980). Women at X-Hazil Sur generally care for small numbers of pigs, turkeys, or chickens. These animals are butchered by male members of the household. Some of the meat is consumed within the household, while the rest is sold locally. Usually this money belongs to the woman. Pork costs approximately $2.67 per kilogram of meat, turkeys approximately $3.33 per kilogram live weight, and chickens cost approximately $3.33-5.00 each (live). Maya women also tend small gardens near the house. Some of the herbs, fruits, and vegetables are consumed by the household, while the rest is sold locally, often door-to-door by small children. These activities provide only a limited income to women as these products are commonly produced by most area residents.

X-Hazil Sur men also undertake several economic activities in order to supplement their subsistence activities and to earn cash and purchase goods. Some of these activities occur on the *ejido*, while others take place in nearby towns and cities. Within the *ejido*, the main economic activity for men is to extract latex from sapodilla trees growing wild in the forest (A. Jorgenson, 1992). Chicle latex is used to produce chewing gum, and has been exported to the United States, Japan, and several European countries for more than 100 years (Otañez Toxqui and Equihua Enriquez, 1981; Dachary and Arnaiz Burne, 1983).

Maya men harvest chicle latex during the rainy season by cutting canals in the bark and collecting the latex in a bag placed at the base of the tree. Men, working independently but as members of a formal cooperative, may process 5-15 trees daily for 3-5 months and earn about $350 per season (Barrera de Jorgenson, 1993). Usually men form teams of 2-4 individuals and work an area of forest for several days before moving on to another site. Men usually leave home each morning and return each afternoon. Rarely, men establish camps in the forest and harvest chicle for 7-14 days before returning to the village. Men usually bring their guns to the tapping site and frequently shoot wildlife between the village and the work site.

Another economic activity for Maya men in Quintana Roo and Ejido X-Hazil y Anexos is to harvest the trees for lumber (Edwards, 1986; Murphy, 1990). Mahogany (*Swietenia macrophylla*) wood is economically valuable and has been harvested primarily for export in the Yucatán Peninsula since the late 1800s (Negreros, 1991; Snook, 1993). Mahogany wood is processed overseas and is used to make items such as furniture, floor tiles, and wall panels. Other species of valuable tropical woods are harvested as contracts are approved by the Government of Mexico. An especially valuable species is *chechem* (*Metopium brownei*), which is used for railroad ties in Mexico. Lumber harvesting occurs during the dry season, and separate work teams locate, fell, trim, and load the trees onto trucks.

Some workers use gasoline-powered chain saws, while others use axes and machetes. Workers often harvest game in the forest while processing trees.

For many years, timber harvested on Ejido X-Hazil y Anexos was shipped to private lumber mills near Chetumal for initial processing before shipping the lumber overseas. In 1989 the *ejido* negotiated the siting of a lumber mill in the village of X-Hazil Sur. The mill owner agreed to train local *ejidatarios* as mill workers, process *ejido* timber there, and after 3-4 years turn over the mill operation to the *ejido*. Presently the mill provides part-time employment to about 75 workers. These workers cut planks and build tables, chairs, and bee hives. While some of these items are purchased locally, most are shipped to Chetumal. The impact of this mill has not been fully felt by *ejido* residents, but already several men have reduced the time spent hunting and in other subsistence activities.

Maya Indians in Quintana Roo have cared for European domestic livestock (i.e., sheep [*Ovis aries*), horse [*Equus caballus*), and cow [*Bos taurus*]) since about 1519 (Hamblin, 1984, 1985; Hamblin and Rea, 1985). Today, about eight teams of men herd cattle on the *ejido*. These herds are relatively small and presently the main focus of the owners is to increase herd size. About once a month, however, a cow is butchered in the village and the meat sold locally for approximately $3.33 per kilogram. Goats also are raised. One man has a herd of about 15 goats and feeds them fresh leaves from the *ramón* (*Brosimum alicastrum*) tree. Eventually these goats will be butchered and the meat sold in Felipe Carrillo Puerto. Another man has about five domestic rabbits and along with his family consumes the meat as circumstances warrant.

Men and women at X-Hazil Sur also tend small stores (five stores in the village offer the basic necessities); weave hammocks from thread bought in stores; sew *huipiles*, white cotton dresses used by women; and tend to special garden plots (*zona frutícola*; 1-3 ha, irrigated, with the land deeded to specific individuals) where fruits and vegetables are grown to be sold outside the village under a special government program. The importance of these activities to X-Hazil Sur residents is limited in that transportation costs are high, outside buyers usually pay low prices, and other villages in the area also produce the same crops at the same time.

Some X-Hazil Sur residents work outside of the *ejido* for wages. For example, about 5-10 men work in Felipe Carrillo Puerto as masons and construction laborers. They earn about $7-10 per day, but the work is part-time. These men live on the *ejido* and tend personal gardens, however, in order to maintain their status as *ejidatarios*. In another example, two brothers have completed their secondary education, learned English, and now work as waiters in an international hotel complex near Tulum. These young men visit X-Hazil Sur frequently, but have lost their *ejidatario* status. Other men have attempted to locate employment outside of the *ejido*, but generally have been unsuccessful. However, in view of the limited economic opportunities in the area, young adults—more than ever before—are graduating from high school, attending technical schools, and obtaining jobs in stores, restaurants, and shoe factories in the large towns and cities (Thompson, 1974).

There are two important considerations regarding subsistence and economic activities: One, these activities occur throughout the year (Figure 2-5). For example, after the end of the chicle tapping season a man may switch to logging or gardening, only to resume chicle tapping later in the year. At no time are these people inactive for an extended period. Two, X-Hazil Sur residents usually engage in several activities at a time. For example, a man may weed his garden during the morning, survey potential garden sites, and gather firewood on his way home.

Subsistence Hunting

Hunting is no longer an important activity for the majority of Maya Indians at X-Hazil Sur in light of the alternative ways to subsist. Many men, however, continue to hunt regularly and harvest a substantial amount of game (J. Jorgenson, 1990). The nature and extent of this hunting will be discussed in subsequent chapters.

Ethos

As with many indigenous people, the worldview of the Maya of X-Hazil Sur has been influenced by many factors, including their history, physical environment economy, and social changes brought about as these people are confronted with the realities of Mexican and international life. To the Maya, the outside world as well as the immediate environment are a source of uncertainty.

Many of the Maya at X-Hazil Sur believe that the world is filled with evil spirits that must be propitiated regularly. Appropriate offerings include praying, lighting a candle, sponsoring a mass, or preparing a special meal. Failure to make an appropriate offering may result in any of a series of unfortunate events, including an accident, crop failure, a sick family member, bad luck while hunting, or the loss of a valuable tool. Offerings often are made on a proactive basis in that a person will make an offering

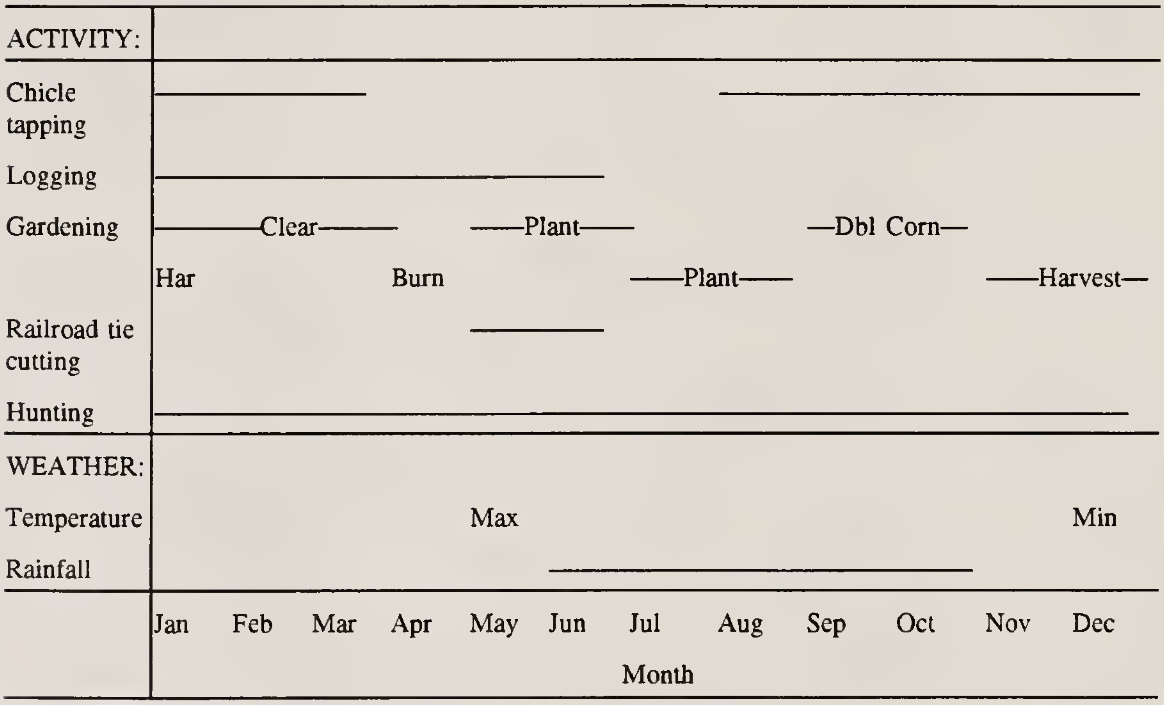

Figure 2-5. Monthly occurrence of subsistence and economic activities in relation to temperature and rainfall (Max = month with highest average temperatures; Min = month with lowest average temperatures; Dbl Corn = double over corn stalks; Har = harvest activity).

in order to avoid potential problems. While many X-Hazil Sur residents considered themselves deeply religious, others professed only limited beliefs.

Several important saints are recognized by the Maya at Ejido X-Hazil y Anexos. During some of these celebrations, especially prior to planting the garden or during an extended dry period, game is taken on special group hunts (*batidas*) and consumed as part of the ceremony. Other saints do not require game. San Juan, for example, is celebrated in June. For several weeks prior to the celebration, representatives of the saint visit surrounding villages and gather food that will be cooked and redistributed during the public ceremony. These representatives go from house to house soliciting corn, chickens, and other groceries. San Miguel, another important saint, is celebrated in February with an extensive ceremony that lasts 10 days. There is a great deal of peer pressure to contribute valuable commodities such as a pig or a sack of corn to San Miguel. Failure to meet these personal promises is viewed by the Maya as an open invitation for revenge by San Miguel.

Religion plays an important role in Maya life. Of the three villages, X-Hazil Sur and Uh-May have small churches, while Chancah Veracruz has a larger church that hosts many regional ceremonies. Separate Catholic masses and traditional Maya ceremonies are held at these sites. Few residents of X-Hazil Sur are fervent believers in the Catholic faith, but parents often bring their children to a priest in order to be baptized. This baptism will facilitate obtaining legal identification papers by the child that are necessary in order to attend school. These Maya see no conflict in adhering to both sets of beliefs and often incorporate Catholic prayers (in Spanish) in the traditional Maya ceremonies.

At X-Hazil Sur, the Maya see outsiders as potentially hostile and dangerous. An adult Maya man will seek security through economic independence for his immediate family. This independence, he believes, is achieved by hard work and looking out for one's self. Most X-Hazil Sur residents are reluctant to give or seek economic aid, or to lend or borrow items from others, and, except for mandatory village chores (*faenas*), they rarely engage in cooperative projects.

Initially I, too, was considered an outsider and viewed with great suspicion by the residents of X-Hazil Sur. During my early visits to the village, I accompanied biologists from my host agency who already had established friendships with X-Hazil Sur residents over several years of visits. In order to undertake my study at X-Hazil Sur, I had to make a formal request at a village meeting (*asemblea*) where the issue was discussed and voted upon. Other outsiders also have been allowed to move into X-Hazil Sur on the condition that they would leave if their presence became objectionable to a large number of residents. This actually occurred a few years prior to my study when an evangelical minister from the United States was asked to leave after problems developed. I fortunately was able to complete my study and left the village on good terms with the residents.

Personal and official relationships for the Maya of X-Hazil Sur operate on a mixture of fear, respect, and confidence. Maya usually can count on their immediate family for support and assistance. Friendships with neighbors and former schoolmates are not as reliable and arguments frequently occur. Shamans, herbalists, midwives, the elderly, shopkeepers, and people in authority generally are treated with respect by all. In dealing with teachers, doctors, government officials, and other non-Maya outsiders, the Maya have a sense of fear and inferiority, and they frequently are abused by those in power.

Ejido residents live a tightly controlled life, and their interpersonal behavior is guarded. Adult men generally are somber and rarely offer important information to other residents or outsiders. This conduct is similar to peasant behavior in Mesoamerica and central Java (Wolf, 1957). At X-Hazil Sur, various groups of men form nightly at stores and the church to discuss village matters. Adult women primarily remain at home where they visit with friends and family while attending to household chores. Social relationships are especially difficult for young adults to establish. After finishing the eighth grade, young men and women have limited opportunities to date and have a hard time meeting potential spouses due to a lack of time, money, and meeting sites. Children also are guarded in their behavior and most children do not greet or smile at outsiders. These behaviors are changing, however, as children learn about other cultures in school and the adults gain more experience with outsiders through visitors such as myself, traveling salesmen, culturally sensitive tourists, and while working outside of the village for wages.

Creativity and artistic expression are not encouraged by the Maya of Ejido X-Hazil y Anexos. During my study, I was aware of only one local painter and a handful of musicians. None of these artists was highly regarded by X-Hazil Sur residents for their talents. In school, children frequently were encouraged to draw, but their parents usually did not appreciate their artwork. A potential outlet for artisans is the DIF store in Felipe Carrillo Puerto, where handicrafts such as hammocks, dresses, weavings, and carvings, are sold to tourists, but no X-Hazil Sur residents have sold items at this store.

The Maya of Ejido X-Hazil y Anexos show a general lack of concern for the future or for self-improvement. Simple matters, such as leaking roofs and losing one's pigs for a few days while they feed in a neighbor's field, are addressed long after they become a problem. Complex problems, such as the declining abundance of game and the determining the equitable use of land by cattle ranchers and horticulturalists, generally are ignored. With respect to self-improvement, only a few families have encouraged their children to seek further education or employment outside of the village, and those individuals who leave subsequently are treated as outsiders.

In spite of a general reluctance by *ejido* residents to ask or seek economic assistance (except from government officials who usually did not insist that the loans be repaid), I was continually asked to give loans against personal items left as security. Occasionally the money was used to purchase necessary items such as food, medicine, or clothing. More often, however, a man would pawn his wife's jewelry in order to buy beer. The local shopkeepers also loaned money or goods against future earnings by village residents. Fortunately, my clients were able to clear all of their debts before I left.

While living in the *ejido* was an interesting experience and my wife and I made many good friends, we also noted several problems that complicated daily life for all. Perhaps the major problem was the immoderate consumption of beer by men and the numerous fights that resulted. This was aggravated by the fact that the men often did not receive any pay until the work was completed even though the job might last several weeks. Men often received 3-6 months earnings in cash at a time. Unfortunately, many of these men would spend much of this money at the local tavern or in Felipe Carrillo Puerto, and within a few days they would be broke again.

A second major problem was that the *ejido* was divided into two main sociopolitical groups. As a result, many problems that needed cooperation by all in the village were not resolved. Initially the division was between two groups of families. One faction was composed of members of a single, extended family that had become somewhat more politically and economically powerful than others in the village. The other faction was composed of families that wanted to obtain that power. Jealousy and animosity often prevented these groups from cooperating in community affairs. The matter was further complicated by competing interests in the villages of Uh-May and Chancah Veracruz.

The conflicts between groups and villages has led to difficulties when it was time to elect village officials, decide on timber harvests, and make work assignments. Usually matters were decided by a vote of *ejidatarios* and little thought was given to compromise or being fair. The minority group always lost and their resentment was apparent as projects were duplicated, poorly completed, or left undone out of spite for those in charge. For example, the village had two bus lines that simultaneously covered the same route. Likewise, X-Hazil Sur had an unfinished village hall, unchlorinated drinking water, and volleyball and basketball courts that lacked lights because residents of one village did not want to pay for recreational activities in another village. In addition, village officials often received complaints from individuals but were unable to organize an effective committee to complain to municipal officials about village problems, for example, incompetent teachers and frequent closings of the local schools. These problems likely will continue until residents learn how to work together in a more cooperative manner.

The picture was not completely bleak, however, as many positive activities also occurred. For example, the village had a baseball team that competed with several other villages and towns. The players had uniforms and provided great entertainment on Sunday afternoons. Village residents also managed to host several dances with live bands during the past few years with the profits going for specific village projects. Further, village officials successfully negotiated the placement of a small lumber mill outside the village in order to process locally harvested timber. In this manner, village residents will obtain greater profits from the trees they harvest. Village officials also initiated a program where about 30 residents will receive government loans and subsidies to grow fruits and vegetables on private holdings. These projects have improved village life greatly during the past few years.

Closing Comments

Recognizing the multidisciplinary nature of this study, I have tried to show the complexity and interrelatedness of the three basic elements of this project; gardens, wildlife, and hunting. No single element can be understood in isolation from the other two. To appreciate these results, it is also imperative to consider the natural, cultural, and socioeconomic environment of the area, how conditions have changed over the past 25,000 years, and what challenges lie in the future. During the next several years, the Maya of Quintana Roo will have to decide what aspects of their culture they wish to maintain and what will be allowed to fade as the area is further developed for logging, tourism, and cattle ranching. If the costs and benefits of the various alternatives are carefully researched by social and biological scientists and clearly explained to the Maya, I would hope that the Maya would choose wisely, but suspect that they might not.

CHAPTER 3
GAME HARVEST BY MAYA HUNTERS IN QUINTANA ROO, MEXICO

Introduction

Studies on the nature and extent of hunting have been identified as a critical need to develop resource management strategies (Posey et al., 1984). These alternative strategies are necessary because traditional approaches used in Europe and the United States have not been successful in response to the loss of pristine habitats, especially tropical forests, and the unregulated harvests of wildlife, especially for commercial purposes (Shaw, 1991). While people have modified their surrounding habitat and harvested wildlife for millennia, the rates at which these activities presently occur have placed the needs of many people in conflict with those of wildlife (Redford and Robinson, 1985, 1991; Robinson and Redford, 1991c). The challenge for conservationists is to identify instances where the goals of natural resource conservation and the goals of indigenous people are compatible.

Previous studies about hunting have treated hunters, wildlife, and the environment in which they occur as separate, independent elements. Traditionally, anthropologists have studied hunting from the point of view of indigenous people and their associated cultural factors. Studies in the Neotropics, for example, have quantified differences between indigenous groups with respect to hunting technique (Hill and Hawkes, 1983; Yost and Kelley, 1983), taboos (McDonald, 1977; Ross, 1978), use of gardens and habitat modification (Linares, 1976; Nations and Nigh, 1980), and hunting regulation (Balée, 1985; Werner, 1983). Biologists, on the other hand, traditionally have studied hunting from the point of view of its effects on the wildlife. Studies in the Neotropics, for example, have quantified differences between wildlife species with respect to changes in behavior (Crawshaw, 1991; Dallmeier, 1991; Mittermeier, 1991), population density (Freese et al., 1982; Peres, 1990), patterns of habitat use (Bodmer, 1989; Bodmer et al., 1988a, 1988b; Fragoso, 1991), and mammal community structure (Glanz, 1991; Janson and Emmons, 1990; Malcolm, 1990). While these studies have provided much specific information about the particular species or indigenous group in question, natural resource managers are still attempting to develop viable, long-term, management strategies. Additional studies are necessary that integrate humans, hunting, and conservation.

An analysis of subsistence hunting by Maya Indians may be valuable in understanding how an indigenous people apparently can exploit wildlife for subsistence purposes. A biological analysis will help understand if this hunting is being conducted in a sustainable manner. Maya Indians have practiced shifting cultivation and subsistence hunting in southern Mexico and Central America since at least 1,500 B.C. (Adams, 1991). Archaeological evidence from Cerro Brujo, in northern Panama, indicates that the species composition and relative abundance of game taken by indigenous people at that site during 960-985 AD is similar to that taken by Maya subsistence hunters today (Linares, 1976). Assuming that hunting practices today are similar to those conducted several centuries ago in the region, and that hunting practices throughout the Maya realm were similar, this suggests that subsistence hunting by Maya Indians may be sustainable and could be used to develop alternative resource management strategies.

The evidence that this hunting could be sustainable was based on an examination of the behavior, species composition, and relative abundance of wildlife at Cerro Brujo compared with their current abundance at other forested Neotropical sites. Linares (1976) noted that certain wildlife species at Cerro Brujo were relatively more abundant than expected, based on an analysis of bones at a village refuse site, when compared with their abundance at other forested Neotropical sites that were not populated by people. According to Linares (1976), these relatively abundant species used the gardens planted by the Cerro Brujo people and benefitted from the interspersion of small gardens in the surrounding forest. Although no data were presented, Linares (1976) postulated that the population density of the species using the gardens was greater because they regularly fed on cultivated crops planted by the hunters. These people subsequently modified their hunting practices and began to specialize on the wildlife species that foraged in the gardens. Linares (1976) called this practice "garden hunting" and defined it as an association between hunters and prey where the prey, due to the garden, benefitted from the additional food resources available and the hunters, due to the garden, benefitted from the additional game available.

The current study was designed specifically to test the relationships comprising garden hunting. More generally, it was designed to compile information about a highly acculturated group of indigenous people practicing subsistence hunting. The results of this and subsequent chapters will be useful in evaluating the specific model of garden hunting. These results also will be useful in developing alternative resource management strategies as the Maya contemplate a shift in subsistence activities from hunting and horticulture to logging, cattle ranching and commercial fruit production.

There were three general objectives for this chapter and several specific hypotheses:

First objective.--Describe the composition and characteristics of the game harvested by Maya hunters at X-Hazil Sur. Several hypotheses were tested: One, the proportion of male game animals taken was equal to the proportion of females taken, per species. Two, the monthly take of mammals and birds was equal among months. Three, the hourly take of mammals and birds was equal among hours. Four, the distribution of take of mammals and birds was equal, among specific time intervals.

Second objective.--Describe the characteristics of the hunters and their weapons. Several hypotheses were tested: One, the age class distribution of hunters was equal to the age class distribution of the general population of males at X-Hazil Sur. Two, the yield of game per outing and hunter-hour was equal between different-sized groups. Three, the mean prey item weight was equal between different types of weapons and by hunter for the seven main hunters, based on the total number of prey taken.

Third objective.--Describe the characteristics of the hunt. Several hypotheses were tested: One, the yield of game per outing and per hunter-hour was equal for different types of hunts. Two, the distribution of kill sites in different vegetation types was equal to the proportion of these types in the study area. Three, the mean kill site distance was equal, by game species and by hunter for the seven main hunters.

Methods

Study Area

The study took place at Ejido X-Hazil y Anexos, Quintana Roo, Mexico, during 1989-1990 (total area = 552.95 km^2; Figure 2-1). Hunting data were obtained from hunters at the village of X-Hazil Sur (19°23'30"N, 88°05'00"W; population = 1,040), the largest of three villages on the ejido (total population = 1,680). The mean annual temperature is about 26°C and the area typically has one dry season (December-May) and one wet season (June-November). Rainfall during 1 January-12 December 1990 was 1,277.3 mm (Figure 2-4). About 88.52% of the *ejido* was categorized as Late Secondary Forest, 6.07% as Plots & Gardens, 5.18% as Early Secondary forest, and 0.23% as Other (Table 2-3). Since about 1915 the area has been occupied by Maya Indians, whose main subsistence activity has been shifting cultivation, primarily corn. Prior to 1915, Maya Indians did not occur in the area.

General Considerations

The key to the successful completion of this project was obtaining the cooperation of village residents and individual hunters. This cooperation was gained over several months and required careful and continuous attention to many local political and social matters that were indirectly related to the field research. These matters were important, however, because it was difficult to separate personal and professional relationships in the village. My ability to obtain hunting data was enhanced by living full-time in the village and participating fully in local affairs.

The results of this study were composed of data about game species taken during outings by hunters from the village of X-Hazil Sur. Reports from hunters in the adjacent villages of Uh-May and Chancah Veracruz were not included due to time and financial constraints, even though they were part of the *ejido* and hunted on areas used by X-Hazil Sur hunters. The working arrangement with hunters was that they would report a kill, regardless of the time or the number of animals taken, and allow it to be weighed and measured before they butchered it. Game processing and hunter interviews usually began within 5-10 min of the notification. In order to avoid problems among hunters and to guarantee hunter anonymity, no details of the hunt were divulged to other village residents. Two unresolvable problems were that not all hunters agreed to participate in the study and not all participating hunters reported all the game they took. These problems will be addressed below.

Another matter to be resolved was how to distinguish between game and nongame species. Hunters at X-Hazil Sur took a wide range of animal taxa for subsistence purposes. However, hunters also captured some species to keep as pets. Other species were killed because they were dangerous (e.g., venomous snakes), killed domestic animals (e.g., *Didelphis* spp.), possessed valuable skins (e.g., Felidae), or were crop predators (e.g., birds of the Psittacidae, Columbidae, and Icteridae families). Although young boys with slingshots frequently killed small animals for target practice, adult hunters did not kill animals for this purpose. In order to focus on species taken for subsistence purposes, local hunters were interviewed to develop a list of primary game species. Game species were defined as taxa that were taken regularly by a large number of hunters and whose meat would be socially acceptable to most X-Hazil Sur residents.

Four taxa were excluded from consideration although they were taken for subsistence purposes by some hunters. Doves (Columbidae) and parrots and parakeets (both Psittacidae) were crop predators and frequently were taken by young boys protecting gardens. These species were excluded because they were not widely consumed by X-Hazil Sur residents. Fish were excluded from this study because only a few residents went fishing, fish generally were available only during a short period of time each year (April-June), and most hunters viewed fishing mainly as a recreational activity where consumption of the meat was of minor importance.

The project had several phases and not all types of data were recorded during the entire study. Initially, data were recorded on hunting outings for game and nongame species. Subsequently, nongame species were excluded from consideration. Effective 31 July 1990, a decision was made to stop recording data for the pocket gopher (*Orthogeomys hispidus* [Geomyidae]) and plain chachalaca (*Ortalis vetula* [Cracidae]). This decision was made for three reasons: One, research priorities had shifted from the hunting inventory to completing other aspects of the project. Two, it became apparent that several hunters were taking these species in order to participate in the study. Three, while frequently taken, these species were of limited value for subsistence purposes, compared with the other game species, due to their small body weight.

Number of Species and Individuals

Animals usually were examined fresh and whole. Animals were identified, weighed, and measured according to standard field procedures. Scales with different capacities and graduations were used to weigh the animals; however, the weights presented here have been rounded off to 0.1 kg. Hunters were queried about the details of the hunt during formal interviews (Appendix D). Interviews usually lasted about 15 min and were conducted either at the field station or the home of the hunter. The primary game identification guides were Leopold (1977) and Peterson and Chalif (1973).

Sex of Game Species

The sex of an animal was determined primarily based on a visual examination of the carcass, but internal organs also were frequently examined, especially for mammals. The sexing of birds in the field was more difficult than sexing mammals, but each species had certain identifying characteristics. For the great curassow (*Crax rubra* [Cracidae]), plumage coloration was used as males are black, while females are reddish-brown (Peterson and Chalif, 1973). For the ocellated turkey (*Agriocharis ocellata* [Meleagridae]), the presence of leg spurs was used to identify males (Leopold, 1977). For the plain chachalaca, the shape and length of the trachea was used. In male chachalacas, the trachea forms a comparatively long loop that extends over the lower abdomen, while in females the loop is short (Delacour and Amadon, 1973). Sexual identification of the thicket tinamou (*Crypturellus cinnamomeus* [Tinamidae]) was based on examination of internal organs by museum specialists at the Universidad Nacional Autónoma de México as the sexes are similar in size and plumage.

Age Class of Game Species

Primary game species were assigned to one of three age class categories: adult, subadult, and young. These categories were based on visual examination of the carcass and on information provided by hunters as strict age class definitions for these species have not been established for Mexico. In general, individuals categorized as adults were defined on the basis of having a large body size; worn fur, teeth, nails, and feathers; and having well-developed reproductive organs. Individuals categorized as young generally were no more than a few months old and were defined on the basis of having a small body size; unworn fur, teeth, nails, and feathers; and having poorly-developed reproductive organs. Individuals categorized as subadults were defined on the basis of having intermediate characteristics. The information provided by experienced hunters was especially helpful in assigning the prey to an age class.

Reproductive condition

The reproductive condition of female birds and mammals was noted to identify when they were gravid or caring for young. Gravid females were identified by a visual inspection of the reproductive tract to locate eggs, embryos, and fetuses. Lactating mammals were determined by squeezing the teats. Brooding birds were determined by having a brood patch. Reproductive tracts also were collected and preserved in 15% formalin for microscopic studies, but they have yet to be analyzed.

Distribution of Take by Month and Time of Day

Data were summarized by month and time of day in order to compare the take of game by hunters. The monthly take of mammals was compared for 17 months, while the take of birds was compared for only 7 months because of apparent reporting problems. At first, most hunters did not want to report taking birds, and then it appeared that some hunters were shooting birds specifically to participate in the study. The hourly take of game animals was compared for 24 h over these time periods. Temporal differences in take between mammals and birds were compared for seven, two-hour intervals: 0600-0759 h, 0800-0959 h, 1000-1159 h, 1200-1359 h, 1400-1559 h, 1600-1759 h, and 1800-0559 h. To ensure adequate sample sizes for statistical comparisons, data were combined in order to have a minimum sample size of five or more individuals per interval.

Age of Hunters

Information about the ages of hunters was obtained from local medical doctors who had conducted annual censuses of village residents. In most cases, ages were obtained from birth certificates, but in some cases they were based on the memory of the respondent.

Identification of Hunters, Hunting Group Members, and Types of Weapons

In order to obtain information from the hunters, it was agreed not to divulge their names or the details of their kills. Hunters were reluctant to cooperate, at first, for various reasons. One, hunting in the study area was a private matter in that game was not considered to be community property and hunters were not expected to share information about game kills or sightings with other residents (cf., Hames and Vickers, 1983). Two, much of the hunting was illegal according to national legislation because some game was taken out of season or in excess of bag limits (cf., SEDUE, in litt.). In order to protect the identity of hunters, specific individuals are referred to by number.

In most cases, cooperating hunters readily acknowledged killing an animal. They also openly provided information about their hunting partners and the weapons used. Noncooperating hunters who were reported to me by third parties often either denied making a kill or only provided limited information about the outing. Every attempt was made to encourage hunters to participate in the study, and anonymity was assured, but the wishes of those who chose not to collaborate were respected.

Seven hunters obtained substantially more game than did the other 77 hunters. The individual results for the main hunters were described in the text and in Appendix E to contrast hunters who harvested a large amount of game versus those who harvested a small amount of game. In all cases, each game kill was attributed to a single hunter. The arithmetic mean prey weight per hunter was defined as the total weight of the prey divided by the number of individual prey items, for each hunter.

The entire list of specimens obtained during the study is listed in Appendix F. This list includes game and nongame species regardless of how obtained.

Types of Hunts

Hunters at X-Hazil Sur used various methods to obtain game. Based on information provided by hunters during the interviews, hunts were assigned to one of four categories: tracking/stalking, stand/platform, trapping, and other.

According to the tracking/stalking method, hunters search for tracks, feathers, or feeding sign as they quietly and slowly walk through the forest or garden. Periodically the hunter sits on a log or rock that provides a clear view of the area and listens for animal sounds. Hunters use this technique during the day and night. During night hunts, hunters use headlamps.

According to the second method, hunters construct a stand or platform in an elevated location and begin using the site a few weeks later, after the animals become accustomed to the structure. Stands and platforms usually are 3-5 m above ground level and include natural forks in trees, free-standing tripods made from tree trunks, or branches fastened to convenient trees. Stands and platforms are located in both the forest and gardens. Structures located in forests usually are adjacent to game trails or positioned near water holes or fruiting trees (e.g., sapodilla trees [*Manilkara zapota*]). Structures located in gardens usually are positioned to take advantage of game trails, garden edges and topography, and the distribution of crops in the garden. Stands and platforms almost always are used during the night.

Two basic types of traps were used to capture mammals: wire snares and deadfall traps. Pocket gophers were trapped using a wire snare placed in the tunnel. Upon activating the snare, the pocket gopher is pulled up against the tunnel ceiling by the wire around its chest and eventually suffocates. The tunnel ceiling is reinforced with small branches to withstand the pressure exerted by the stick used as a spring. Pacas (*Agouti paca* [Agoutidae]) and agoutis (*Dasyprocta punctata* [Dasyproctidae]) were captured using a deadfall trap constructed of rocks and boards at the entrance of their burrows or caves where they sought refuge. Caves and burrows frequently were discovered by dogs that accompanied hunters. Both types of traps often were set near work sites in the forest or garden and along trails between the site and the village. Traps have the advantage of being able to capture an animal in the absence of the hunter. Disadvantages with using traps are many and include a tendency for the trap to be activated prematurely and the potential for ants, other hunters, and wild and domestic animals to steal or damage the prey.

Hunting Outings

For purposes of this study, a hunting outing was defined as any activity that resulted in the taking of a game animal for subsistence purposes. Unsuccessful outings were not recorded. Some outings were exclusively for hunting, while others also included nonhunting activities such as logging, *chicle* tapping, tending the garden, and gathering firewood.

This definition of a hunting outing, based on the taking of a game animal, was necessary for several reasons: One, hunters did not report unsuccessful hunts. Two, hunters often engaged in other activities before or after a hunt. Three, hunters and nonhunters often carried firearms to the forest or garden, even though their intent was not to hunt. Four, hunters did not necessarily have to depend on firearms to take game as they could use dogs, traps, rocks, machetes, and heavy branches. Five, hunters were open to changing their plans to work or hunt in response to changing events. For example, strong winds or a rain storm could delay or terminate a hunt, while the accidental discovery of game animals in the garden could convince hunters to initiate a hunt. For these reasons data were taken only on successful hunts.

The duration of a hunting outing was defined as the difference between the departure and arrival times of the hunter to his home. Many hunters had watches and could accurately provide this information. Other hunters would estimate their times of departure, kill, and return, or relate them to local events such as moonrise, sunrise, arrival of the village bus, or a television program that was on when they departed or returned. Outing duration included travel time to and from the kill site, and any additional time spent in activities such as resting, eating, or preparing a stand or platform while away from home, but only during that specific outing. This definition may appear excessively inclusive, but is justified for two reasons: One, due to the interspersion of roads, trails, gardens, and forest, game animals potentially could be taken almost anywhere in the *ejido*. Two, game frequently was encountered while the hunter was engaged in other activities. In those few instances when the hunter indicated that he also engaged in nonhunting activities during the outing and definitely was not able to hunt or pursue game, the duration time was adjusted accordingly. In those few cases when a hunter wounded an animal, returned home, and resumed the search with additional help, the combined hunt, travel, and search times were considered as a single outing. The determination of hunting outing duration was facilitated by the hunter immediately reporting a game kill.

Vegetation Types and Land Uses

According to aerial photograph interpretation and a ground survey conducted by foresters of the Plan Piloto Forestal (now named Plan Estatal Forestal), there are six vegetation types and three land uses on the *ejido* (Ing. Marcelo Carreón Mundo, in litt.). In order to characterize the *ejido* and kill sites for this study, these categories were condensed into four land use/vegetation types (Table 2-3; Figure 2-5):

> One, the category identified as "Plots & Gardens" was composed of active gardens (*milpas*), home gardens (*huertos* and *hortalizas*), and fruit and vegetable plots in the special corridor along the highway (*parcelas*). These areas generally were located near the village and along roads and trails in the forest. Gardens generally were ≤ 2 ha in size, used 1-2 y before being abandoned, and were separated from one another (see Chapter 6 for additional information about gardens). Plots were irrigated, 0.5-

1.0 ha in size, included a house site, and are used to grow fruits and vegetables for commercial purposes on a full-time basis. All of the plots were adjacent to each other in the corridor along Route 307, between the village of Uh-May and the turn-off to X-Hazil Sur.

Two, the category identified as "Early Secondary Forest" (*huamiles* and *acahuales*) was composed of regrowth areas on sites that had repeatedly been used as gardens during the past 25-50 y. This category also included cattle corrals and pastures as these areas had undergone the same clearing/burning process used to make gardens. In Early Secondary Forest, the stem density of trees and herbaceous plants was greater than in Late Secondary Forest (see below), while the basal area was less than in Late Secondary Forest (Barrera de Jorgenson, 1993). Early Secondary Forest areas generally were located near roads and trails, but tended to be at greater distances from the village than were the plots & gardens. Left undisturbed, Early Secondary Forest eventually becomes Late Secondary Forest through the process of succession.

Three, the category identified as "Late Secondary Forest" was composed primarily of low- and medium-height semi-evergreen forest (*monte alto* and *monte bajo*), but also included sinkholes (*cenotes*), ponds (*bajos* and *lagunas*), and seasonal wetlands (*sabanas*). The forest in this category had not been used as gardens for at least 50-75 y (if ever at all), according to the oldest residents of X-Hazil Sur. In Late Secondary Forest, the stem density of trees and herbaceous plants was less than in Early Secondary Forest, while the basal area was greater than in Early Secondary Forest (Barrera de Jorgenson, 1993). Ponds, sinkholes, and seasonal wetlands were included in this category because they were quite small, not used for gardens, and widely interspersed in the forest. Areas of Late Secondary Forest typically were located along the *ejido* boundary and furthest from the village.

The category identified as "Other" included the three village sites and forest clearings (*rodales*) used during logging to sort, trim, and load trees onto trucks. Sites in this category generally would not be good game habitat due to repeated use by people and the substantial nature and extent of the habitat alteration.

Kill Site Locations and Distance from X-Hazil Sur

The location of each kill site was determined after evaluating the information provided by hunters, including the route taken, habitat type of the kill site, distances along each road and trail, and any landmarks (e.g., trails, gardens, sinkholes, and road markers). This information was compared with aerial photographs (Instituto Nacional de Estadística Geográfica e Informática, February 1985, 1:37,000 scale), topographic maps (Instituto Nacional de Estadística Geográfica e Informática, 1987, 1:50,000 scale), and personal knowledge of the area. Kill sites were plotted on base maps (scale = 1:50,000). The minimum distance between the village and the kill site was measured as a straight line from the water tank, about 500 m west of the village plaza. The water tank was used as a landmark because it was permanent, highly visible, and indicated on topographic maps of the area.

Care must be exercised when interpreting the information about kill site locations because many of the sites were based on estimated distances or features that could not be clearly located on the maps or aerial photographs. Locations within 2-3 km of X-Hazil Sur, along Route 307 (marked every kilometer), or near well-known landmarks probably were accurate to within 500 m, while other locations probably were accurate to within 1-2 km.

The distribution of kill sites in Late Secondary Forest was compared with the combined total of kills in areas categorized as Plots & Gardens, Early Secondary Forest, and Other. This was necessary in order to have an adequate sample size of kills. Given the small surface area categorized as Other and the similarity between Early Secondary Forest and Plots & Gardens, it was decided to combine these categories. For the species analyses, the expected number of kills per vegetation type was determined by multiplying the total number of kills by the proportion of each vegetation type.

Minimum Harvest and Catchment Areas

The minimum harvest area for each taxa was defined as the region encompassing the kill site locations for that taxa. The minimum catchment area for each hunter was defined as the region encompassing the kill site locations of all game taken by that hunter. The minimum catchment area was determined only for the seven main hunters. Since hunters did not always report the entire area searched, the minimum catchment area reported here is conservative and includes only the region encompassing the actual kill site locations. The harvest and catchment areas were determined using the minimum convex polygon method (Hayne, 1949; Mohr, 1947) and measured using a compensating polar planimeter.

Use of Dogs

Dogs frequently accompanied hunters to the forest and gardens, and often located or killed game. Usually this game was collected and brought home to be eaten by the hunters. The presence of dogs on hunting outing, the game taken, and the total number of dogs with the hunting party were recorded.

Statistical Methods

Parametric and nonparametric tests were used to analyze hunting data. Sex of game taken was tested against an expected 1:1 (male:female) ratio using the χ^2 test. Homogeneity for the distribution of take by month was tested using the χ^2 test. For mammals, the expected monthly take was equal to 1/17 of the total take, while for birds it was 1/7 of the total take because hunters apparently did not report their bird kills during 1989. The distribution of take by hour was tested using the χ^2 test and assumed that the hourly take was equal to 1/24 of the total take. The distribution of take of birds versus mammals by time of day was tested using the χ^2 test. The yield of game per outing and per hunter hour by hunter group size and type of hunt was tested using the Kruskal-Wallis test (χ^2 approximation). The actual hunter group size was used to calculate the yields, but data for groups $\geq$ 5 individuals were summarized in the tables. For type of hunt, only tracking/stalking and stand/platform were compared because for the other two types of hunts yield was essentially independent of hunter group size. The distribution of kill sites in Late Secondary Forest versus Plots & Gardens, Early Secondary Forest, and areas categorized as Other were compared for homogeneity with the χ^2 test. The mean kill site distance was compared among species and hunters for the top seven hunters using the Kruskal-Wallis test (χ^2 approximation). Mean prey body weight by hunter and by type of weapon was compared using the Kruskal-Wallis test (χ^2 approximation). The following statistical terms were used: χ^2 = chi-square (χ^2 approximation for Kruskal-Wallis test); $\bar{x}$ = mean, SE = standard error, n = sample size, d.f. = degrees of freedom, and P = probability-value. Specific P values were presented, rather than base a determination of significance on a set alpha-value. All statistical analyses were conducted using SAS (SAS Institute Inc., 1988), and unless stated were two-tailed.

Voucher Specimens

Voucher specimens were deposited at the Museo de Vertebrados (M. en C. Carmen Pozo, Director), Centro de Investigaciones de Quintana Roo, Chetumal, Quintana Roo, México, and the Museo de Zoología (M. en C. Adolfo G. Navarro Siguenza, Director), Facultad de Ciencias, Universidad Nacional Autónoma de México. México, DF, México. Specimen identifications were assisted by J. E. Escobedo Cabrera, E. M. Figueroa, H. Flores, A. G. Navarro Siguenza, and L. L. Paniagua (in litt.).

Limitations of the Data Sets

There are several problems that must be considered in interpreting the data obtained during this study. Perhaps the most serious problem was the procedure used to obtain game kill reports. This study was based on voluntary reports of game kills provided by hunters. As might be expected, not all hunters provided reports and not all cooperating hunters reported all of their kills. This problem was addressed in many ways in order to improve the likelihood of receiving a report, including: employing local residents as field assistants; living full-time in the village of X-Hazil Sur; maintaining good relations with hunters and their families; and repeatedly conducting informal, follow-up interviews with hunters to confirm or clarify information obtained from others. These practices greatly facilitated obtaining timely and accurate reports of game kills. Based on my calculations, conversations with hunters, and on information provided by village residents, the reported number of game animals taken probably represents about two-thirds of the total game harvest, by number of individuals, at X-Hazil Sur during the course of my data collection.

A second problem was with the measurement of time and distance (e.g., duration of the hunting outing or the location of the kill site). While in many cases the hunter knew the exact location and distance to the kill site as well as the time of day when the animal was killed, in other cases these measures were estimated. These estimates, however, were probably quite reliable as the Maya at X-Hazil Sur were very familiar with measuring time and distances while conducting other subsistence activities, such as logging and working in gardens. Distance and time estimates recorded during this study were constantly checked against maps, aerial photographs, knowledgeable local residents, and by making site visits to many of the gardens, kill sites, and work areas in the forest.

A third problem was the normality and independence of the data observations. It rapidly became apparent during the study that the nature and extent of hunting depended greatly upon the biases and preferences of the hunters. For example, some hunters went hunting on a relatively frequent basis, while others went infrequently, and some hunters had several years of experience, while others were just learning. In addition, some hunters were highly dependent upon the game they obtained as food, while others were not as dependent as they had domestic animals (e.g., pigs, chickens, turkeys, and cattle) to supplement their diet. As a result of these differences, there likely were several types of hunters and hunting outings at X-Hazil Sur, that when quantified, would not be independent or normally distributed. These differences among individuals, however, were not important here as the research focus was on the *ejido* as a whole and the patterns exhibited by those hunters.

The assumptions of data normality, independence, and equal variance were avoided by using the nonparametric, Kruskal-Wallis test when comparing groups of hunters or game species, instead of the more-rigorous, parametric ANOVA test. Given that it was not necessary to meet these assumptions in order to make the various comparisons, the Kruskal-Wallis procedure could test for differences under the circumstances at X-Hazil Sur.

Results

Composition and Characteristics of the Harvest

Number of species and individuals. A total of 584 game animals were reported taken by hunters at X-Hazil Sur during 17 months (June 1989-October 1990; Table 3-1). Mammals comprised 66% (n = 385 individuals) of the reported total and birds 34% (n = 199). No reptiles, amphibians, or insects were collected by hunters for personal consumption, except that honey was consumed when encountered in the forest. A small number of fish (*Cichlasoma urophthalmus* [Perciformes, Cichlidae]) were taken by hunters during April-June of each year, but these data were not included here. This total also does not include animals collected by local residents for other reasons, harmful or distasteful animals that were killed and abandoned, or game species found dead on the road (except for three instances of fresh game that was consumed by hunters).

Eight mammalian and four avian taxa were taken for subsistence purposes. The coati (*Nasua nasua* [Procyonidae]; n = 167 individuals) was the most frequently taken mammal, followed by the pocket gopher (n = 53) and the paca (n = 47), while the plain chachalaca (n = 167) was the most frequently taken bird (Table 3-1).

The game taken by hunters provided residents of X-Hazil Sur with a substantial amount of meat. The total body weight of the 584 animals was 2,700.1 kg (Table 3-1). Of this total, 95% was from mammals and 5% was from birds. Three mammalian taxa combined, white-tailed deer (*Odocoileus virginianus* [Cervidae]; 709.0 kg total weight, $\bar{x}$ = 29.5 kg), collared peccary (*Tayassu tajacu* [Tayassuidae]; 618.5 kg total weight, $\bar{x}$ = 15.5 kg), and coati (504.9 kg total weight, $\bar{x}$ = 3.0 kg) provided 68% of the total weight. This meat was primarily consumed by the individual hunters and their immediate families (ca. 400 people), but small quantities were also sold locally (see below).

Sex of game species. Males and females were not taken in equal proportions. For all mammals combined, significantly more females were taken than males (χ^2 = 5.3150, d.f. = 1, $P <$ 0.025; Table 3-2). However, for birds, more males were taken than females (χ^2 = 11.8128, d.f. = 1, $P < 0.005$). While mammals and birds were each dominated by a single taxon, the patterns these higher taxa groupings exhibited were generally the same as those exhibited by individual species.

The ratio of males to females taken varied between game species. For mammals, more females were taken than males for seven of the eight taxa (Table 3-2). The mean sex ratio for all mammals combined was 1:1.3:0.0 (males:females:unknown). For mammals, the greatest disparity between males and females taken was for the white-tailed deer (1:3.8:0.0; χ^2 = 8.1667, d.f. = 1, $P <$ 0.005). The ratio of males to females taken also was significantly different for the agouti (1:1.8:0.1; χ^2 = 2.9412, d.f. = 1, $P < 0.10$) and pocket gopher (1:1.7:0.1); χ^2 = 3.7692, d.f. = 1, $P < 0.10$).

For birds, more males were taken than females for three taxa, but the only significant difference was for the plain chachalaca (1:0.6:0.1; χ^2 = 11.7771, d.f. = 1, $P < 0.005$; Table 3-2). The mean sex ratio for all birds combined was 1:0.6:0.1. This suggested that for the plain chachalaca there was a significant difference in the harvest by sex, while there was no difference for the great curassow.

Table 3-1. Reported number of individuals taken, mean weight (kg), and total weight (kg) of game taken by Maya hunters at X-Hazil Sur, Quintana Roo, Mexico, during June 1989-October 1990.

Game species	Total number individuals taken		Rank order (no.)[a]	Mean weight (kg)	Total weight (kg)[b]	Rank order (wt.)[c]
a) Mammals						
Pocket gopher	53	(51)[d]	3	0.4	22.3	10
Paca	47		4	5.8	274.8	4
Agouti	35		6	2.8	96.8	6
Coati	167		1	3.0	504.9	3
White-lipped peccary	3		12	31.4	94.3	7
Collared peccary	40	(36)	5	17.2	618.5	2
Brocket deer	16		8	15.6	250.0	5
White-tailed deer	24	(22)	7	32.2	709.0	1
Total mammals	385	(377)			2570.6	
% of all game	66				95	
b) Birds						
Thicket tinamou	13		9	0.4	4.9	12
Great curassow	13		9	3.1	40.1	9
Plain chachalaca	167		1	0.4	64.9	8
Ocellated turkey	6		11	3.3	19.7	11
Total birds	199				129.5	
% of all game	34				5	
Mammals & Birds	584	(576)		4.7	2700.1	

[a] Rank order based on total number of individuals taken.
[b] Total weight was determined by summing the weights of the individual prey items. The degree of precision varied between species as different scales with assorted capacities and graduations were used.
[c] Rank order was based on the total weight of the individual prey items taken.
[d] Values in ( ) indicate number of individuals weighed if weight not available for all individuals in taxa.

Table 3-2. Sex and age class of game taken by hunters at X-Hazil Sur.

	Sex (no. inds.)					Age class (% inds.)		
Game species	Males	Females	Unknown	χ^2	P[a]	Adults	Subadults	Young
a) Mammals[b]								
Pocket gopher	19	33	1	3.7692	< 0.100	86.8	13.2	0.0
Paca	22	25		0.1915	< 0.900	70.2	29.8	0.0
Agouti	12	22	1	2.9412	< 0.100	65.7	25.7	8.6
Coati	80	86	1	0.2169	< 0.900	57.5	37.7	4.8
White-lipped peccary	1	2		----[c]		66.7	33.3	0.0
Collared peccary	19	20	1	0.0256	< 0.900	67.5	30.0	2.5
Brocket deer	10	6		1.0000	< 0.500	75.0	25.0	0.0
White-tailed deer	5	19		8.1667	< 0.005	66.7	25.0	8.3
Mammals combined	168	213	4	5.3150	< 0.025	69.5	27.5	3.0
b) Birds[b]								
Thicket tinamou	7	4	2	----[c]		92.3	7.7	0.0
Great curassow	7	6		0.0769	< 0.900	84.6	15.4	0.0
Plain chachalaca	100	57	10	11.7771	< 0.005	89.2	10.2	0.6
Ocellated turkey	3	3		----[c]		66.7	33.3	0.0
Birds combined	117	70	12	11.8128	< 0.005	83.2	16.7	0.1

[a] d.f. = 1 for all χ^2 tests.
[b] Individuals with sex undetermined were not included in this analysis.
[c] Test not performed because at least one of the cells had < 5 individuals.

Age class of game species. The proportion of adults, subadults, and young taken by hunters varied between species. For all mammals combined, adults were taken more frequently than subadults or young (55% adults, 43% subadults, and 2% young; Table 3-2). The greatest difference by species was with the pocket gopher (87% adult and 13% subadult), but the percentage of adults versus subadults and young also were high for brocket deer (*Mazama americana* [Cervidae]; 75% adult and 25% subadult) and white-tailed deer (67% adult, 25% subadult, and 8% young).

Adult birds also were taken more frequently than subadults or young overall and for each of the four taxa (83% adults, 17% subadults, and 0% young (Table 3-2). Few subadult or young birds were taken.

Reproductive condition. Reproductively active females were harvested by hunters. Among mammals, none of the pocket gophers ($\underline{n}$ = 33 females; see Table 3-2 for numbers of females) or white-tailed deer that were harvested were determined to be gravid. Pregnant white-lipped peccaries (100% with embryos or fetuses), agoutis (27%), pacas (20%), brocket deer (17%), collared peccaries (15%), and coatis (2%) were noted (Figure 3-1). About 32% of the white-tailed deer and 20% of the pacas taken were lactating.

Among birds, none of the great curassows or ocellated turkeys that were harvested were determined to be gravid. Thicket tinamous (25%; see Table 3-2 for numbers of females) and plain chachalacas (5%) with eggs were noted (Figure 3-1). None of the birds taken had a brood patch. The reproductive condition of many birds and mammals was impossible to determine due to damage that resulted from stomach shots by hunters.

Distribution of take by month. The take of game animals by month varied during the study. For both mammals (χ^2 = 157.54, $\underline{d}.\underline{f}.$ = 16, $\underline{P} < 0.005$) and birds (χ^2 = 28.56, $\underline{d}.\underline{f}.$ = 6, $\underline{P} < 0.005$), there were significant differences among months.

Game species generally were taken throughout the year, but the majority of individuals of a taxon tended to be taken by hunters during shorter periods of three-five months each (Figures 3-2 & 3-3). It is important to note the length and timing of these periods were different for each species. The

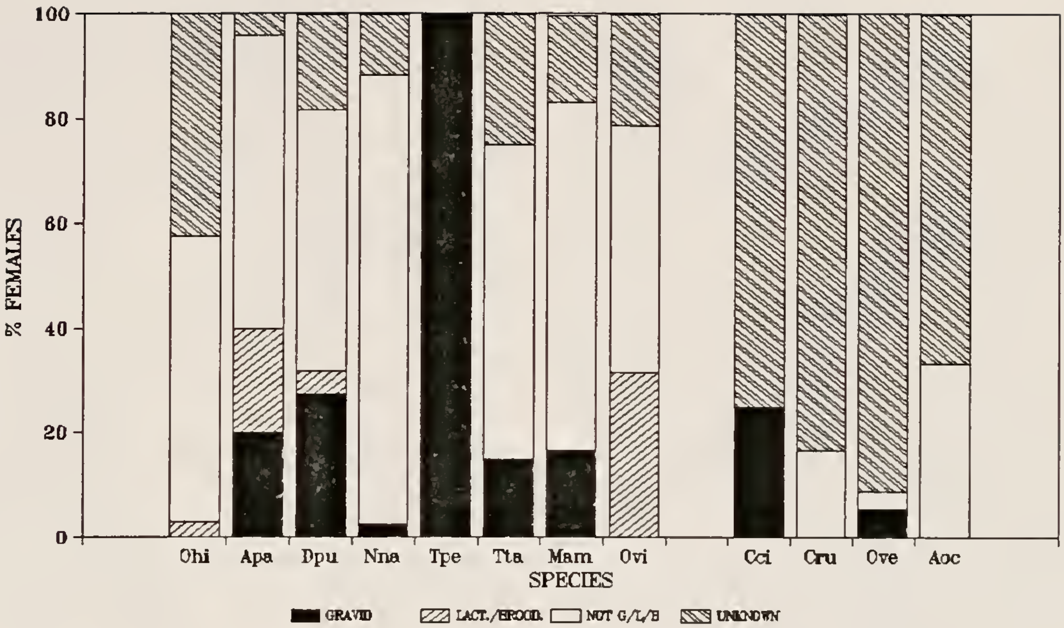

Figure 3-1. Reproductive status of female birds and mammals. Animals were categorized as gravid, lactating/brooding, not gravid/lactating/brooding, or unknown (abbreviations correspond with scientific name; Ohi = pocket gopher, Apa = paca, Dpu = agouti, Nna = coati, Tpe = white-lipped peccary, Tta = collared peccary, Mam = brocket deer, Ovi = white-tailed deer, Cci = thicket tinamou, Cru = great curassow, Ove = plain chachalaca, and Aoc = ocellated turkey).

coati, for example, was taken primarily during 9/90-10/90 (48% of the take during two months), and to a lesser extent during 11/89-3/90 (37% of the take during five months; Figure 3-2D). The brocket deer and white-tailed deer also followed this pattern in that take was relatively high during a 2-4 months and then low or absent during the remaining months (Figure 3-3C & 3-3D).

Birds were taken primarily during 1/90-7/90 (Figure 3-4). For the thicket tinamou, great curassow, and the ocellated turkey take was primarily during one-two month periods that differed between species. Take of the plain chachalaca was primarily during 1/90-3/90 (50% of total), but data collection for this species was discontinued after 7/90.

Gravid female mammals were taken throughout the study. Agoutis with embryos or fetuses were noted during 5 months (January, March, April, June, and August 1990), while gravid pacas were

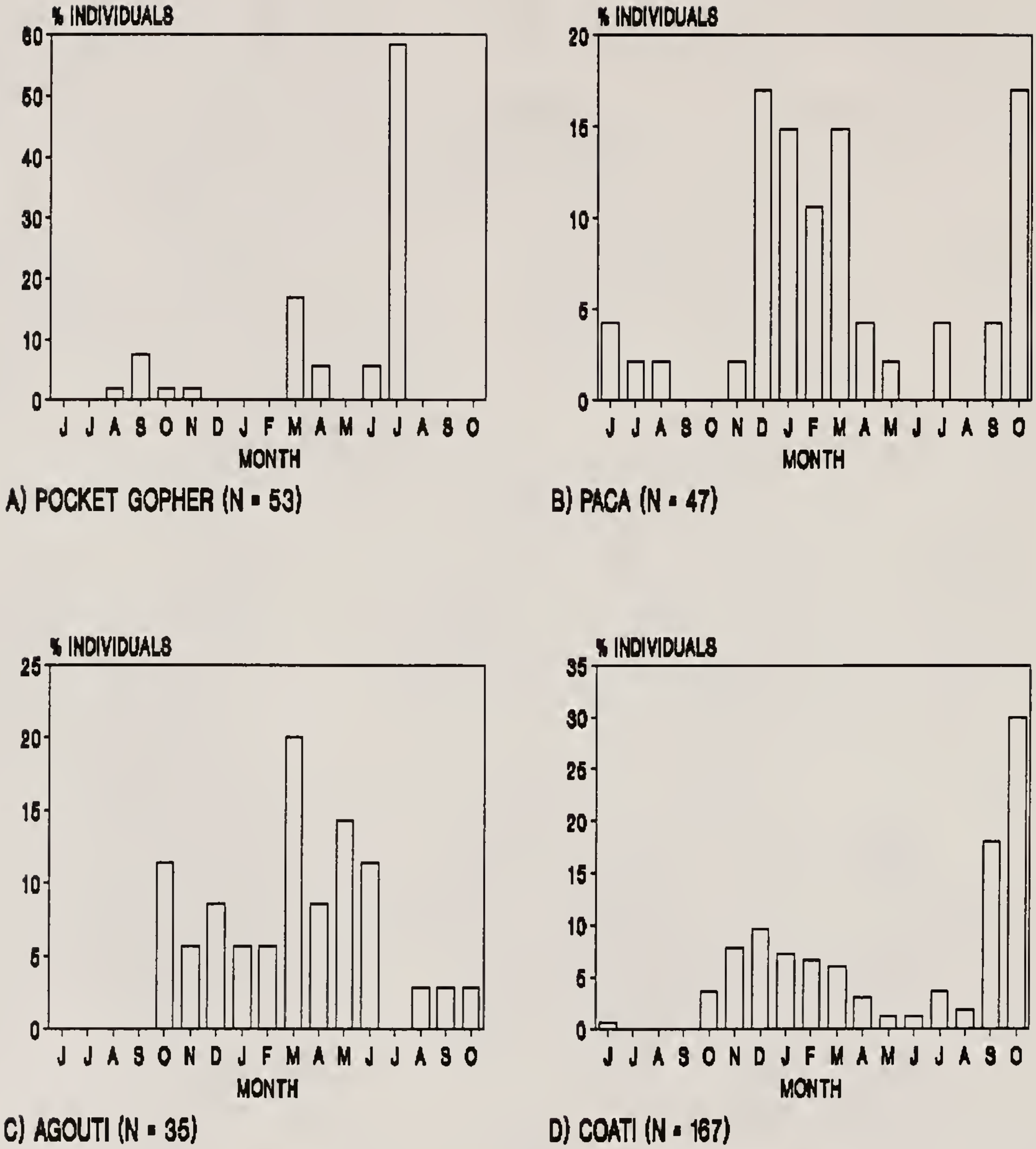

Figure 3-2. Reported monthly harvest levels for a) pocket gopher, b) paca, c) agouti, and d) coati.

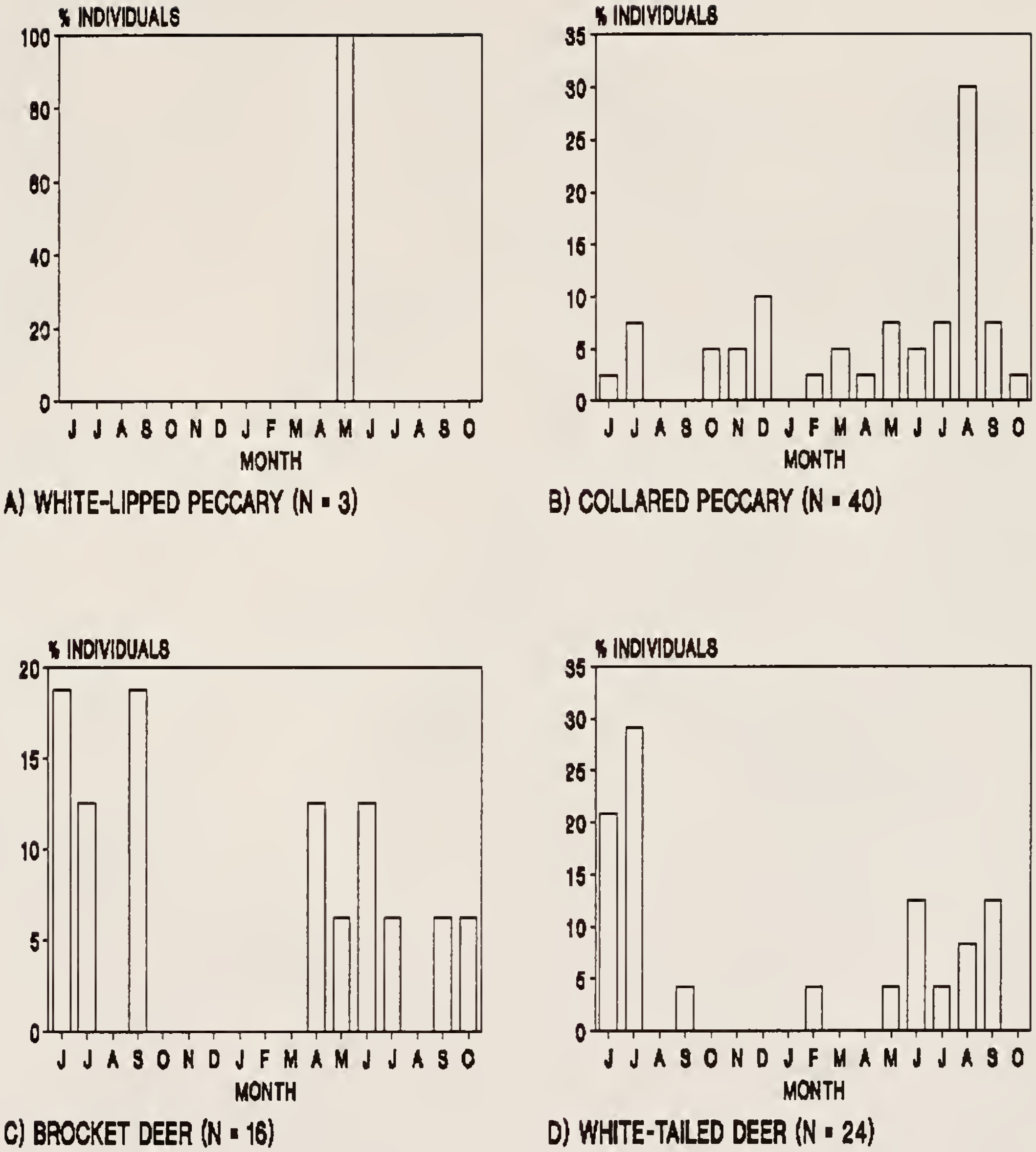

Figure 3-3. Reported monthly harvest levels for a) white-lipped peccary, b) collared peccary, c) brocket deer, and d) white-tailed deer.

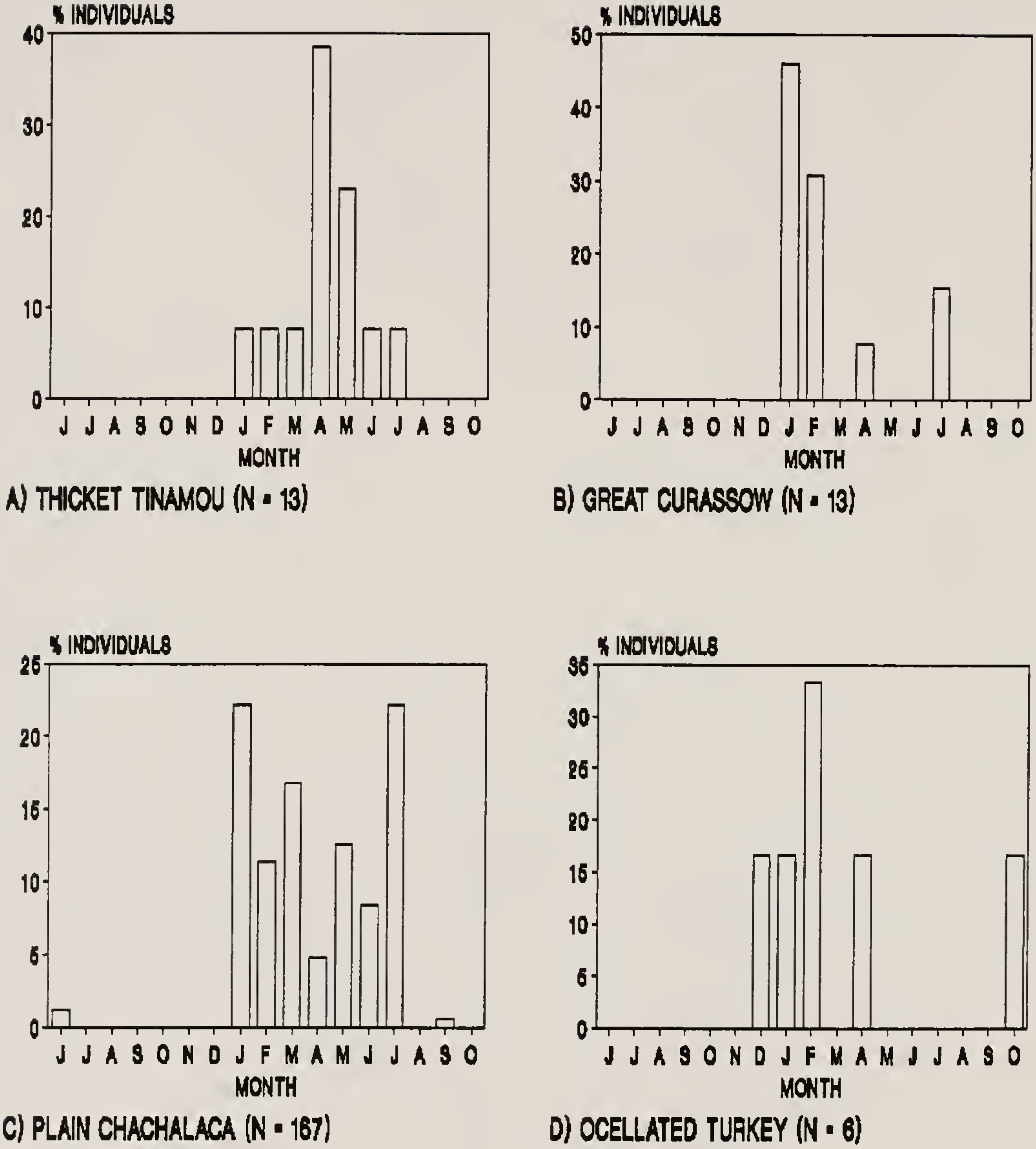

Figure 3-4. Reported monthly harvest levels for a) thicket tinamou, b) great curassow, c) plain chachalaca, and d) ocellated turkey.

recorded during 4 months (November 1989, January, April, and September 1990; Figure 3-5). Gravid females for other species of mammals were recorded only during 1-3 months, each. Among birds, plain chachalacas were encountered with eggs during 3 months (January, April, and May 1990), while the thicket tinamou was recorded with eggs during 1 month (May 1990; Figure 3-6). No eggs were encountered in the other species of birds.

Distribution of take by time of day. The distribution of take by time of day for game animals varied. For both mammals (χ^2 = 289.12, d.f. = 23, $P < 0.005$) and birds (χ^2 = 444.90, d.f. = 23, $P < 0.005$), there were significant differences among hours. This suggested that there were times of the day when mammals and birds were more likely to be taken than during other times.

Mammals were taken during 22 of the 24 hours of the day (Figure 3-7). The greatest number of mammals was taken during 0800-0859 h when 56 (15% of mammals) individuals were taken. Mammals usually were taken during 0600-1759 h when 325 (84%) individuals were taken. This period roughly corresponded to daytime. Birds were taken during 17 of the 24 hours. Take of birds occurred primarily during two periods: 0600-0859 h, when 109 (55% of birds) individuals were taken, and 1400-1759 h, when 48 (24%) individuals were taken. These two periods corresponded to early morning and late afternoon. For the seven intervals, there was a significant difference in the proportion of take by time interval between mammals and birds (χ^2 = 166.17, d.f. = 6, $P < 0.005$). This suggested that the times when mammals were taken were not the same times as when birds were taken.

The distribution of take by time of day varied by species. The ocellated turkey was taken primarily at dawn (50% of take during 0400-0659 h). Two species, pocket gopher (100% during 0400-1659 h) and plain chachalaca (71% during 0400-1159 h), were taken primarily at dawn and during the day. The coati, white-lipped peccary, collared peccary, brocket deer, thicket tinamou, and great curassow, were taken primarily during the day (≥ 50% during 0700-1659 h). One species,agouti, was taken primarily at dusk and during the day (89% during 0700-1959 h). The paca (70% during 1700-0359 h) and white-tailed deer (63% during 1700-2359 h) were taken primarily at dusk and during the night.

Species	Reproductive condition[a]	Month (1989-1990)																
		J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O
Pocket gopher	G														G			
	L																	
Paca	G						G		G			G					G	
	L								L	L	L							L
Agouti	G								G		G	G		G		G		
	L										L							
Coati	G										G				G			
	L																	
White-lipped peccary	G										G							
	L																	
Collared peccary	G					G					G					G		
	L																	
Brocket deer	G																G	
	L																	
White-tailed deer	G																	
	L	L	L											L				

[a] Reproductive condition:
G = gravid with eggs, embryos, or fetuses (determined by visual inspection).
L = lactating.

Figure 3-5. Monthly occurrence of gravid or lactating female mammals.

Species	Reproductive condition[a]	Month (1989-1990)																
		J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O
Thicket tinamou	G												G					
	B																	
Great curassow	G																	
	B																	
Plain chachalaca	G								G			G	G					
	B																	
Ocellated turkey	G																	
	B																	

[a] Reproductive condition:
G = gravid with eggs, embryos, or fetuses (determined by visual inspection).
B = brooding.

Figure 3-6. Monthly occurrence of gravid or brooding female birds.

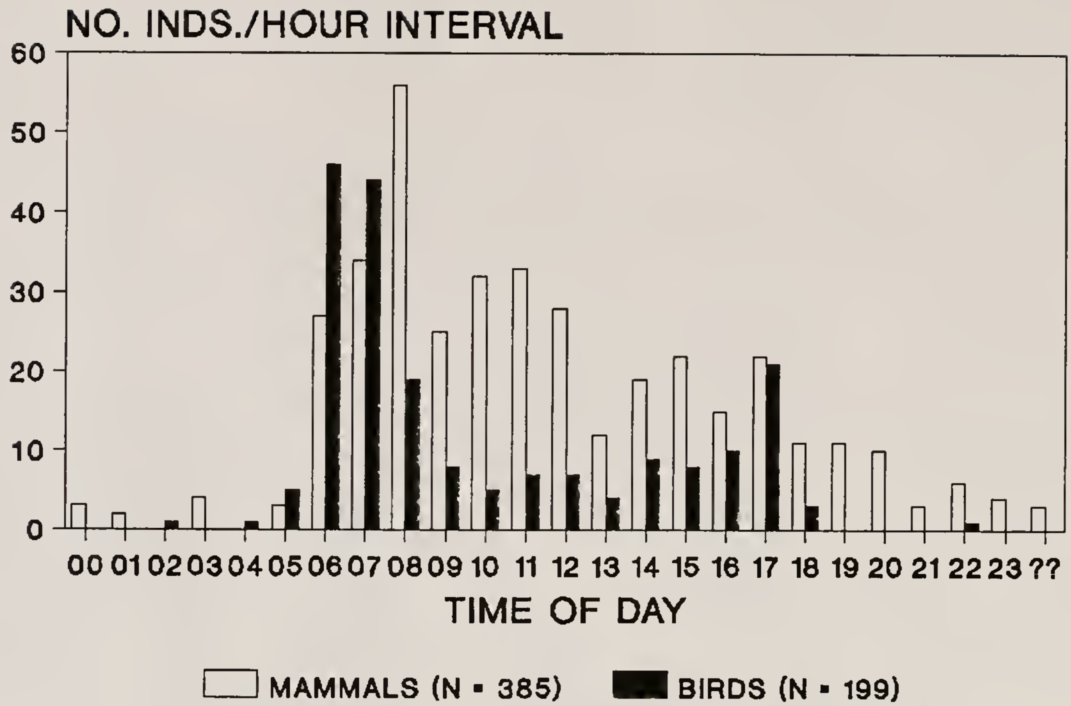

Figure 3-7. Number of game birds and mammals taken per hour.

Characteristics of the Hunters and their Weapons

Age and identification of hunters. The 1989 population of X-Hazil Sur was 950 residents, 479 males and 471 females in about 200 households (Dr. Juan Chi and Dr. Norbierto Ramírez Morales, in litt.). A total of 86 hunters (84 men from about 70 households and 2 women from 2 households) reported taking game. One woman was 16 y old and reported taking only one collared peccary, while the other woman was 36 y old and reported taking only one agouti. The male hunters ranged in age from 10 to 60 y old ($\bar{x}$ = 29.1 y, SE = 1.2 y, n = 84; median = 28 y) and constituted 18% of the male population.

The distribution of hunter's ages differed from that of the male population of X-Hazil Sur as a whole. The age distribution of males at X-Hazil Sur was pyramidal in shape with relatively few men in the older age classes and proportionally more in the younger age classes (Figure 3-8). However, the age distribution of hunters at X-Hazil Sur was different in that 79% of the male hunters were in age classes 15-39 y, versus 40% of the total male population. This suggested that there is an age range when men practice hunting, but outside of that range few continue the activity.

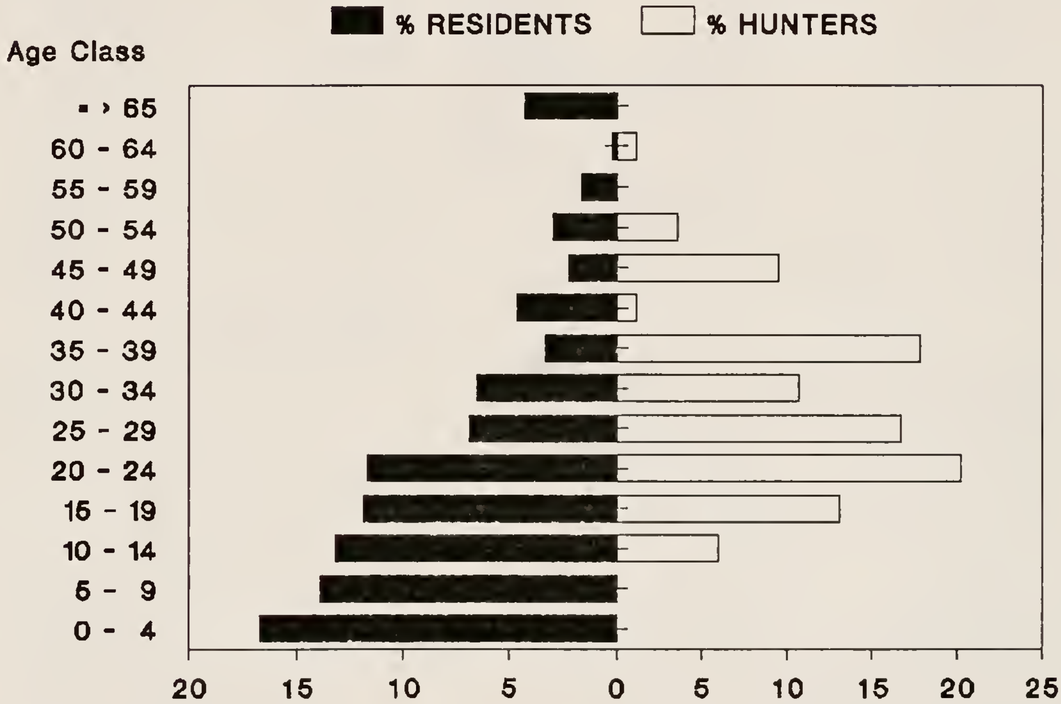

Figure 3-8. Age class (years) distribution of male residents (539 residents based on 1992 census) and male hunters (84 hunters during 1989-1990 study).

The number of game kills per hunter varied greatly. The mean number of kills per hunter during the 17 month period was 7.0 (SE = 1.4; n = 86). Hunter number 35 took the greatest number of animals at 85 individuals, while 35 hunters reported only 1 kill each (Figure 3-9). Seven hunters reported 27 or more kills each and accounted for 54% of the total number of individuals taken (Appendix E).

There was a significant difference in the mean prey weight among the seven main hunters (χ^2 approximation = 96.15, d.f. = 6, $P < 0.0001$). Hunter # 6 had the greatest mean prey weight ($\bar{x}$ = 7.8 kg, SE = 1.4 kg, n = 61), followed by hunter # 1 ($\bar{x}$ = 3.8 kg, SE = 0.7 kg, n = 44) and

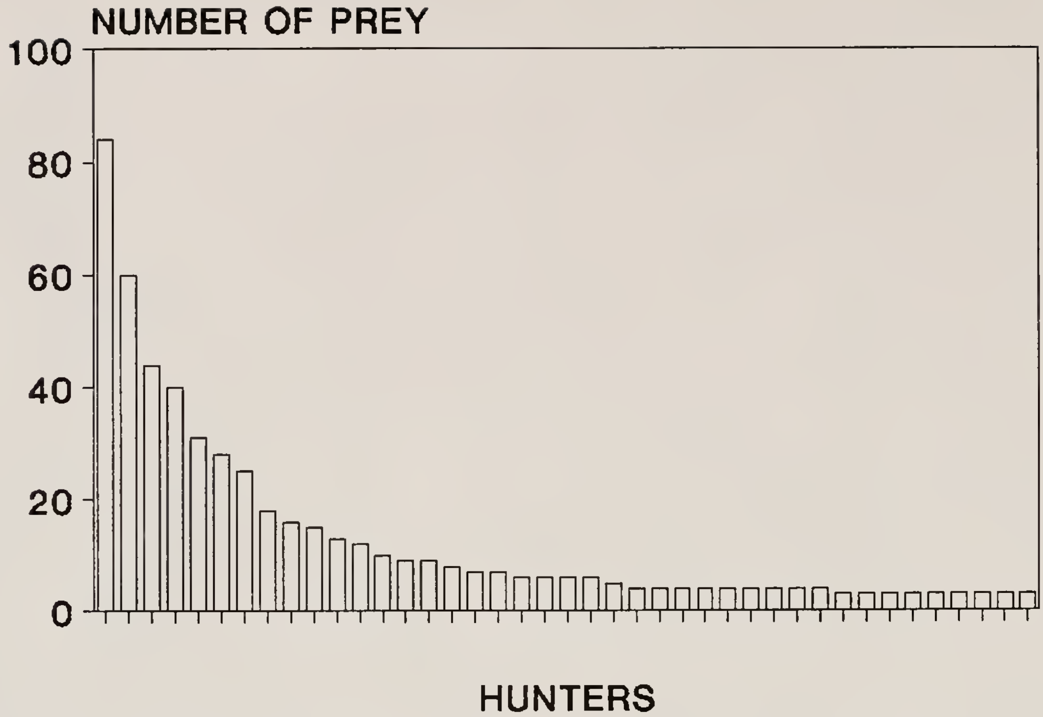

Figure 3-9. Number of kills per hunter. A total of 47 hunters had only one or two kills each and are not shown here.

hunter # 35 ($\bar{x}$ = 3.2 kg, SE = 0.3 kg, n = 85; Appendix E). This suggested that even among the main hunters there were substantial differences in the size of the prey they harvested.

Hunter group size. Hunters pursued game individually or collectively. The mean group size of hunters was 1.7 individuals (SE = 0.0.05, n = 417). Individual hunters conducted 58% of the hunts and took 55% of the game by number, while hunters in groups ≥ 5 people conducted 3% of the hunts and took 3% of the game (Table 3-3).

The mean number of prey taken per hunting outing ranged from 1.3 to 1.8, but there was no significant difference among these values with respect to hunter group size (χ^2 approximation = 5.6909, d.f. = 4, $P < 0.2235$; Table 3-3). There was, however, a significant difference between mean number of prey taken per hunter hour with respect to hunter group size (χ^2 approximation = 109.66, d.f. = 4, $P < 0.0001$). Hunter groups with a single hunter harvested 0.4 prey per hunter hour, while larger groups harvested game at less than half that rate. This suggested that one-two prey are taken per outing and that single hunters take game at a higher rate per hunter hour than hunters in larger groups.

Types of weapons. Hunters used various types of weapons to take game. Approximately 39% of the game was taken by 22 caliber rifles. Game also was taken by traps (9%), shotguns (23% by 16 gauge shotguns, 19% by 20 gauge shotguns, < 1% by 12 gauge shotguns), and methods classified as unknown or other (e.g., dogs, rocks, and machetes; 10%).

Rifles and shotguns have been used by hunters at X-Hazil Sur since the early 1900s, when the area was settled (M. Aban Noh, pers. comm.). With the exception of traps, snares, and machetes, none of the older hunters could recall what kinds of weapons their ancestors used. Rifle hunters now primarily used long-rifle and long-rifle hollow point shells (E. Cab Can, pers. comm.). Shotgun hunters primarily used 3F (9 balls per cartridge) and 4F buckshot (12 balls per cartridge; B. Can Chi and M. Aban Noh, pers. comm.). This size of buckshot was sufficiently powerful to kill a deer at 40 m distance in an open field.

Hunters generally did not use a specific type of weapon to take a specific type of game. With the exception of the white-lipped peccary (*Tayassu pecari* [Tayassuidae]; 100% taken by 20 gauge shotgun) and the pocket gopher (100% taken by traps or other/unknown), game taxa were taken with several types of weapons (Figure 3-10). For the white-lipped peccary, brocket deer, collared peccary, and paca, shotguns accounted for 62-100% of the kills per taxon. For the coati (58% by individuals) and agouti (54% by individuals), rifles and weapons categorized as other (especially dogs and machetes) accounted for more than half of the kills per taxon, but shotguns also were used. White-tailed deer were taken by shotguns (83%) and weapons classified as other/unknown (17%), but not by rifle. Among birds, the ocellated turkey (100% by individuals) and the great curassow (69% by individuals) were taken primarily by shotguns, while the plain chachalaca (75% by individuals) and thicket tinamou (62% by individuals) were taken primarily by rifle.

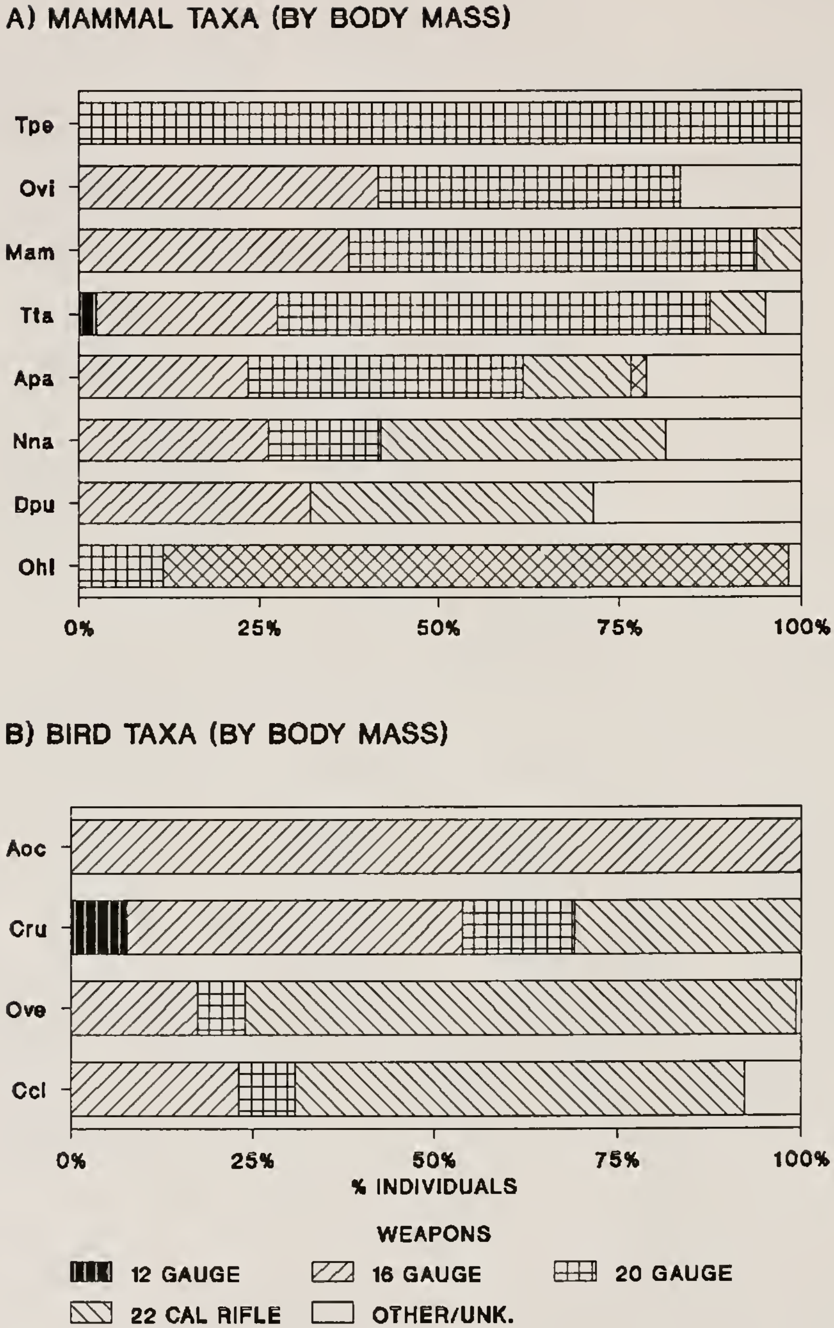

Figure 3-10. Take of mammals and birds according to type of weapon used. Species arranged by mean body mass (see Table 3-1 for body mass; se Figure 3-1 for key to species abbreviations).

There was a significant difference in the mean prey weight for each weapon type (χ^2 approximation = 167.49, d.f. = 5, P < 0.0001; Table 3-4). The 12 gauge shotgun, though used only twice, had the greatest mean prey weight ($\bar{x}$ = 21.4 kg, SE = 18.65, n = 2), while the 20 gauge shotgun had the second greatest mean prey weight ($\bar{x}$ = 10.4 kg, SE = 1.06, n = 110). This suggested that shotguns were used to take the heaviest prey, while 22 caliber rifles and traps were used to take the lightest prey.

Characteristics of the Hunt

The typical hunt was a short foray that lasted only a few hours, took place within the *ejido*, and involved only a minimal amount of preparation. Hunters generally used bicycles to move about and carry game. Except for hunters working overnight at *chicle* camps or those working at gardens or ranches located far from the village, game was brought back to the village.

Hunting outings. Hunters reported taking game on 419 hunting outings (Table 3-5). The tracking/stalking method was used by successful hunters about 79% of the time, by outing, and comprised 64% of the time, by duration of hunt. The total duration of successful hunts was 2,858.1 h ($\bar{x}$ = 7.1 h, SE = 0.33, n = 409). The mean group size was 1.7 hunters and was similar for the three hunting methods: tracking/stalking, stand/platform, and trapping. The mean number of game animals taken was 1.39 individuals per outing and 0.29 individuals per h. About 82% of the game was taken during tracking/stalking hunts.

Hunting yield was compared for two methods: tracking/stalking and stand/platform. There was no significant difference between the mean number of prey taken per outing (χ^2 approximation = 0.4632, d.f. = 1, P < 0.4961) and the mean number of prey taken per hunter hour (χ^2 approximation = 0.6791, d.f. = 1, P < 0.4099). This suggested that each of the two methods, where hunters were specifically involved in hunting and were not distracted by other activities, were equally effective in obtaining game.

Table 3-3. Hunter group size and characteristics of successful outings by hunters at X-Hazil Sur.

Hunter group size	Total number outings[a]		Total duration outings (h)	$\bar{x}$ duration outings (h)	SE duration outings (h)	Total hunter hours	Total number game taken	Number inds. game/outing	Number inds. game/hunter hour
1	242	(231)	1571.8	6.8	0.48	1571.8	320	1.32	0.41
2	114		783.6	6.9	0.48	1567.2	161	1.41	0.16
3	33		266.3	8.1	1.10	798.8	56	1.70	0.11
4	16		170.5	10.7	1.83	682.0	29	1.81	0.15
≥ 5	12	(11)	66.0	6.0	1.08	574.5	16	1.33	0.04
Unknown	2		---	---	---		2	1.00	---
Total	419	(405)	2858.2			5194.2	584		
$\bar{x}$				7.1	0.33			1.39	0.29

[a] Outing duration was not obtained for all outings. Values in ( ) indicate number of outings when duration was known if not available for all outings in each hunter group size category.

Table 3-4. Mean prey body weight (kg) by type of weapon for game species taken at X-Hazil Sur.

Type of weapon	Prey weight (kg)	SE	n
12 gauge shotgun	21.4	18.65	2
16 gauge shotgun	5.9	0.73	130
20 gauge shotgun	10.4	1.06	110
22 caliber rifle	1.8	0.17	226
Traps	0.6	0.14	51
Other/unknown	5.7	1.31	57
Total	2700.1		576
$\bar{x}$	4.7	0.34	

The number of game animals taken per outing generally was low. During about 75% of the outings, only a single mammal or bird was taken (Table 3-6). The greatest number of mammals taken in a single outing was seven (all coatis), while the greatest number of birds taken in a single outing was four (all plain chachalacas). Mixed bags, containing both mammals and birds, were reported for only nine outings.

Kill site locations and vegetation types. Game birds and mammals were not taken in the four vegetation types in the proportion in which these types occurred (Appendix G). For five of the eight mammalian taxa and all of the avian taxa, take was primarily in a single vegetation type, while the remaining three mammalian taxa frequently were taken in two or three vegetation types.

When analyzed descriptively, several generalizations were noted. For mammals, the white-lipped peccary (100.0% of kill sites), collared peccary (58%), and brocket deer (50%) were taken primarily in sites categorized as Late Secondary Forest (Appendix G). Sites categorized as Plots & Gardens were the main kill sites for two taxa, the white tail deer (63%) and agouti (49%), but the coati (47%), pocket gopher (42%), and paca (34%) also were frequently taken in these areas. For birds, the great curassow (92%) and thicket tinamou (77%) were taken primarily in sites categorized as Late Secondary Forest, while the plain chachalaca (87%) was taken primarily in sites categorized as Early

Table 3-5. Type of hunt and characteristics of successful outings by hunters at X-Hazil Sur.

Type of hunt	Total number outings[a]	Total duration outings (h)	$\bar{x}$ Hunter group size	SE Mean hunter group size	Total hunter hours	Total number inds. taken	Number inds. game/ outing	Number inds. game/ hunter hour
Tracking/ Stalking	331 (327)	1819.0	1.8	0.11	3482.2	478	1.44	0.32
Stand/ Platform	33 (32)	204.4	1.6	0.10	345.1	41	1.24	0.24
Trapping	43 (41)	802.9	1.6	0.15	1282.7	51	1.19	0.09
Other	12 (5)	31.8	2.7	0.88	84.2	14	1.17	0.37
Total	419 (405)	2858.1			5194.2	584		
$\bar{x}$		7.1	1.7	0.05			1.39	0.29

[a] Outing duration was not obtained for all outings. Values in ( ) indicate number of outings when outing duration and hunter group size were known if not available for all outings in each type of hunt category.

Table 3-6. Combinations of game mammals and birds taken per outing by hunters at X-Hazil Sur.

		Number of birds/outing					
		0	1	2	3	4	Total[a]
Number of mammals/ outing	0		95	20	12	4	131
	1	218	5	3			226
	2	43	1				44
	3	10					10
	4	3					3
	5	2					2
	6	2					2
	7	1					1
Total[b]		279	101	23	12	4	419

[a] Number of outings with from 0 to 7 mammal kills per outing.
[b] Number of outings with from 0 to 4 bird kills per outing.

Secondary Forest and the ocellated turkey (50%) was taken primarily in sites categorized as Plots & Gardens (Appendix G).

When analyzed statistically, the distribution of take, by species, for seven species of game for Late Secondary Forest versus the other three vegetation categories combined was significantly different from that expected, based on the proportions of those two vegetation types in the *ejido* (χ^2 = 23.4-358.1, $\underline{P} < 0.005$; Table 3-7). For the pocket gopher, paca, agouti, coati, collared peccary, brocket deer, and plain chachalaca, a significantly greater proportion of the take took place in areas categorized as Plots & Gardens, Early Secondary Forest, or Other/unknown than would be expected. Among the species with an adequate sample size to permit testing, no species was taken in Late Secondary Forest at the expected frequency.

Minimum catchment area and mean kill site distances. The minimum catchment area over which hunting occurred could not be precisely determined because only successful outings were reported and the total extent of outings was not always reported. Recognizing this, perhaps the best estimate for minimum catchment area would be the actual size of the *ejido* (552.95 km^2; O. Guatemala Biempica, in litt.) as 581 of the 584 kills were on the *ejido*. The problem with using this value is that hunters from X-Hazil Sur generally hunted only in the western and southern two-thirds of the *ejido* (ca. 370 km^2), while hunters from the villages of Uh-May and Chancah Veracruz (not surveyed during this study) usually hunted in the northeastern one-third of the *ejido*.

The minimum harvest area over which game was taken differed among game species. The two largest harvest areas were observed for the coati (251.8 km^2) and the collared peccary (211.5 km^2), while the smallest harvest area observed was for the ocellated turkey (4.8 km^2; Table 3-8). This suggested that species such as the coati and the collared peccary were widely distributed and harvested in the *ejido*, while others, such as the ocellated turkey, either had a limited distribution or were widely distributed, but harvested only in a limited area. On a more general level, this suggested that game was taken on only about 45-67% of the study area.

There was a significant difference between the mean kill site distances by species (χ^2 approximation = 58.924, d.f. = 11, $P < 0.0001$). The three species with the greatest mean distances between the village and the kill sites were birds: ocellated turkey (7.6 km), great curassow (7.5 km), and thicket tinamou (6.6 km), while the pocket gopher (3.4 km) had the smallest mean distance (Table 3-8). The ocellated turkey had the greatest minimum kill site distance (5.6 km), followed by the great curassow (2.5 km). This suggested that, on average, game birds were taken at greater distances from X-Hazil Sur than were game mammals.

The greatest distance between a kill site and X-Hazil Sur was 17.5 km for a collared peccary, while four species were taken within 1 km of the village (Table 3-8). Twenty-five percent of all kills were within 2.5 km of X-Hazil Sur, 50% within 4.8 km, and 75% within 7.2 km.

Table 3-7. Percent frequency of game kill sites in Late Secondary Forest versus all Combined/Early Secondary Forest and χ^2 test results for the game taken by hunters at X-Hazil Sur.

Game species	Percentage of kill sites by vegetation type: Late Secondary Forest (88.5%)[a]	Combined/ Early Secondary Forest (11.5%)[b]	χ^2	P	n
a) Mammals					
Pocket gopher	5.7	94.3	358.1	< 0.005	53
Paca	34.0	65.9	137.3	< 0.005	47
Agouti	31.4	68.6	112.3	< 0.005	35
Coati	44.9	55.1	312.5	< 0.005	167
White-lipped peccary	100.0	0.0	----[c]		3
Collared peccary	57.5	42.5	37.9	< 0.005	40
Brocket deer	50.0	50.0	23.4	< 0.005	16
White-tailed deer	12.5	83.3	----[c]		26
% Mammals combined	36.9	63.2	1010.2	< 0.005	385
b) Birds					
Thicket tinamou	76.9	23.1	----[c]		13
Great curassow	92.3	7.7	----[c]		13
Plain chachalaca	6.0	94.0	1119.4	< 0.005	167
Ocellated turkey	33.3	66.7	----[c]		6
% Birds combined	17.1	82.9	999.3	< 0.005	199
% All game species combined	30.1	69.7	1958.9	< 0.005	584

[a] Values in ( ) indicate the percentage of the study area in each vegetation type. Total area = 552.95 km^2.

[b] The category Combined/Early Secondary Forest was composed of the vegetation types classified as Early Secondary Forest, Plots & Gardens, and Other.

[c] χ^2 test not performed because at least one of the two expected cells had < 5 observations.

Table 3-8. Minimum harvest area (km^2) and mean distance (km) between X-Hazil Sur (water tank) and kill sites of primary game species taken by hunters at X-Hazil Sur.

Game species	Minimum harvest area (km^2)	Kill site distance (km)			
		$\bar{x}$	SE	Range	n
a) Mammals					
Pocket gopher	66.8	3.4	0.41	0.3-16.4	53
Paca	131.7	5.6	0.49	1.2-15.8	47
Agouti	54.7	4.3	0.50	0.3-11.5	35
Coati	251.8	5.8	0.26	1.4-16.6	167
White-lipped peccary	----[a]	4.0	0.00	4.0	3[a]
Collared peccary	211.5	6.3	0.62	1.3-17.5	40
Brocket deer	89.3	6.5	1.25	1.3-16.4	16
White-tailed deer	63.0	4.6	0.90	0.7-16.4	23[b]
b) Birds					
Thicket tinamou	73.5	6.6	1.33	1.0-16.8	13
Great curassow	59.0	7.5	1.21	2.5-16.2	13
Plain chachalaca	112.0	5.5	0.40	0.4-16.3	167
Ocellated turkey	4.8	7.6	0.89	5.6-11.3	6
All species combined		5.5	0.17	0.3-17.5	583

[a] All three individuals killed at a single site.
[b] n = 23 instead of 24 due to one unknown kill site.

Table 3-9. Minimum catchment area (km^2) and mean kill site distance (km) from X-Hazil Sur (water tank), by hunter, for 315 game animals taken by the seven main hunters versus all other hunters combined at X-Hazil Sur.

Hunter No.[a]	Minimum catchment area (km^2)	Kill site distance (km) $\bar{x}$	SE	Range	n
35	53.0	4.9	0.22	1.2-12.0	85
6	28.3	5.0	0.34	0.4-10.0	60[b]
1	37.3	5.4	0.35	1.0- 9.2	44
18	51.9	2.9	0.29	1.2- 9.8	40
9	68.1	4.3	0.84	1.1-16.2	31
62	7.2	4.3	0.64	0.5-11.3	28
98	45.1	13.3	1.04	1.8-16.3	27
All other hunters		5.5	0.17		268
All hunters combined		5.6	0.27	0.3-17.5	583

[a] Arranged in rank order by number of kills.
[b] n = 60 instead of 61 due to one unknown kill site.

The minimum catchment areas differed among the seven main hunters. The individuals with the largest catchment areas were hunter # 9 (68.1 km^2), hunter # 35 (53.0 km^2), and hunter # 18 (51.9 km^2), while hunter # 62 (7.2 km^2) had the smallest minimum catchment area (Table 3-9).

There was a significant difference in mean kill site distances by hunter for the seven main hunters (χ^2 approximation = 83.786, d.f. = 6, $P < 0.0001$). The individual with the largest mean distance between the village and the kill sites was hunter # 98 (13.3 km), while hunter # 18 (2.9 km) had the smallest mean distance (Table 3-9).

Use of dogs. Dogs assisted hunters by locating or killing game. Seventeen hunters reported using a total of 59 named or individually recognizable dogs. Dogs accompanied hunters on 72 outings (17% of outings) and a total of 127 game animals were taken. The mean number of dogs per outing for this subset was 3.9 (SE = 0.19, n = 72). The coati (95 individuals) was the most frequently taken game species when dogs accompanied hunters, followed by the paca (12), agouti (7), collared peccary (7), plain chachalaca (3), brocket deer (1), white-tailed deer (1), and great curassow (1). Five of the seven main hunters reported using dogs (hunters # 6, 18, 35, 63, and 98), while two did not (hunters # 1 and 9).

Discussion

Composition and Characteristics of the Harvest

Maya Indians have practiced subsistence hunting for at least several thousand years. This study demonstrated that although the Maya of X-Hazil Sur, Quintana Roo, Mexico, have become highly acculturated, many still practice subsistence hunting. In addition, this study also demonstrated those species of game that were hunted during 1989-1990 were essentially the same as those hunted by the prehistoric Cerro Brujo people about 1,000 y ago (cf., Linares, 1976). This suggested that subsistence hunting continues to be an important social and economic activity for the Maya. It also implied that the hunting was conducted in such a way that the wildlife resource was not extirpated. Thus, Maya hunters and the techniques they employed may provide insight into how to manage hunting and wildlife populations in areas where the game has been extirpated or seriously depleted.

Number of species and individuals. The primary game species for Maya hunters at X-Hazil Sur were mammals and birds. Some fish were harvested, while reptiles, amphibians, and insects were not taken for subsistence purposes, except that honey was consumed when encountered. This contrasted with other indigenous groups in Mexico that--in addition to birds and mammals--took substantial quantities of fish, insects, reptiles, and amphibians. For example, Lacandon Maya Indians in the state of Chiapas consumed a wide variety of amphibians and reptiles (Galleti, n.d.; Gongora-Arones, 1987; March M., 1987), while Mixteca Indians in the state of Oaxaca (Parra Lara, 1986) consumed large quantities of iguanas (*Ctenosaura pectinata*) and crabs (*Cardisoma crassum*). Mestizos throughout Mexico also consumed a wide variety of fish, reptiles, and crustaceans (Mellink et al., 1986; Reyes Castillo, 1981; Santana et al., 1990).

Elsewhere in the Neotropics, indigenous and mestizo groups also consumed prey other than mammals and birds. For example, iguanas (*Iguana iguana*) and river turtles (*Dermatemys* spp., *Kinosternon* spp., and *Pseudemys* spp.) were taken by Maya hunters in Belize for meat (Frost, 1974, 1977). In Nicaragua, Miskito Indians consumed large quantities of fish (e.g., *Arius melanopus* and *Bagre marinus*), shrimp (*Penaeus* spp.), and marine (*Chelonia mydas* and *Eretmochelys imbricata*) and freshwater (*Pseudemys* spp.) turtles (Nietschmann, 1972, 1973, 1979). Fish (27 spp.) and turtle and iguana eggs were taken by Creole mestizos in Costa Rica (Frost, 1974). In Guatemala, Maya Indians consume ants (J. E. Jiménez, pers. comm.). Fish, insects, reptiles, and amphibians were also widely taken by mestizos and indigenous peoples in South America (Beckerman, 1983; Chernela, 1985; Dufour, 1987, 1990; Hames, 1979; Hill and Hawkes, 1983; Posey, 1987; Redford and Robinson, 1987; Stocks, 1983; Vickers, 1984). These studies suggested that Maya hunters at X-Hazil Sur used fewer classes of animals as game than were used by other Indian or mestizo groups in the Neotropics.

Among the birds and mammals taken by X-Hazil Sur hunters, relatively few species were harvested compared with the number of species taken by other indigenous peoples. Maya hunters In Quintana Roo took four species of birds and eight species of mammals. Miskito Indians in Nicaragua also took relatively few prey species (about 25 species; Nietschmann, 1972), while Siona-Secoya Indians in Ecuador (Vickers, 1991), Ye'kwana and Yanomamo Indians in Venezuela (Hames, 1979; Saffirio and Hames, 1983), Yuquí Indians in Bolivia (Stearman, 1984, 1990), and Aché Indians in Paraguay (Hill and Hawkes, 1983) each took about 50-60 species of game. Clearly, Maya hunters at X-Hazil Sur took fewer species of mammals and birds as game compared with other indigenous groups.

While a subsistence hunter's diet would depend in great measure upon the potential prey species available, the concentration upon a few species birds and mammals by Maya hunters at X-Hazil Sur, although other potential game taxa also were found in the area, but not taken, suggested at least three possibilities; one, Maya hunters were quite selective in the prey they took; two, the other taxa were not available; and three, hunters were able to supplement their diet by purchasing canned meat and caring for domestic animals.

The possibility that Maya hunters were selective in the game they harvested cannot be addressed fully as the study was not designed to measure hunter game preferences. The coati and plain chachalaca were the two taxa most frequently taken by hunters at X-Hazil Sur, by number of individuals, but there was no indication that these species were preferred by hunters. Other, less frequently taken species, such as the ocellated turkey, great curassow, brocket deer, white-tailed deer, and white-lipped peccary, however, were highly prized by Maya hunters, but rarely taken due to their scarcity and difficulty with which they were encountered.

If given a choice, most hunters at X-Hazil Sur indicated that they would prefer to harvest a great curassow, brocket deer, or white-tailed deer. These choices correspond with Maya game preferences throughout the Yucatán Península (Burns, 1983; Medíz Bolio, 1987). The reasons why these taxa were preferred by hunters included the large amount of meat obtained from the deer (see Table 3-1) and the skill necessary to obtain a great curassow due to its reclusive habits (see Table 3-8 and Appendix G).

The possibility that many game species widely taken elsewhere in the Neotropics, but not by Maya hunters at X-Hazil Sur, suggest cultural differences among indigenous groups and will be discussed more fully in Chapter 4, where data about the number of game species and their densities in the study area will be presented. This will permit a comparison of the availability of game with the harvest of game. However, data for plants (Flores-Villela and Gerez-Fernández, 1989) and reptiles (Lee, 1980) suggested that species diversity and density may be naturally low in the Yucatán Peninsula due to several abiotic factors, including rainfall gradients, recent geologic age, and relatively flat topography. These factors also may have influenced Maya hunters through the number of species of birds and mammals on the peninsula and their population densities.

The relatively small number of game species taken by hunters at X-Hazil Sur was unexpected when compared with (1) the archeological record and (2) the other species of birds and mammals found locally, but not taken for subsistence purposes. This evidence suggests a change in Maya hunting patterns over time. According to archeological studies at Cozumel, a large island off the northeastern coast of Quintana Roo, the following taxa were taken by the Maya during 100-1500 A.D., prior to the arrival of the Spanish: about 40 taxa of fishes and crabs, 4 taxa of amphibians (frogs and toads), 10 taxa of reptiles, 38 taxa of birds, and 16 taxa of mammals (Hamblin, 1984, 1985; Hamblin and Rea, 1985). While many of these taxa were found in ceremonial and administrative buildings and may have been taken for these purposes, the fact that others were found in housemounds suggested that these specimens were taken for subsistence purposes. Although Cozumel is located on the Caribbean Sea and X-Hazil Sur is located about 50 km inland, a comparison between sites is appropriate because of their proximity (ca. 175 km), similar climate and vegetation, and settlement patterns. Other archeological studies in the Yucatán also indicated that the diet of the prehistoric Maya was much more diverse than that of present day Maya (Wing, 1974; Wing and Steadman, 1980).

The relatively small number of game species taken by hunters at X-Hazil Sur was also unexpected when compared with the other species of birds and mammals found locally, but not taken for subsistence purposes. For example, the following mammals occur in Quintana Roo (Leopold, 1977; Navarro et al., 1990) and are widely taken for subsistence purposes throughout the Neotropics (e.g., Hames, 1979; Stearman, 1990), but were not taken by Maya hunters at X-Hazil Sur; squirrel (*Sciurus* spp.), armadillo (*Dasypus novemcinctus*), tapir (*Tapirus bairdii*), howler monkey (*Alouatta pigra*), spider monkey (*Ateles geoffroyi*), kinkajou (*Potos flavus*), tayra (*Eira barbara*), and opossum (*Didelphis virginiana*). This pattern of occurring in Quintana Roo, but not being used for subsistence purposes also was the case for many taxa of birds. Hunters at X-Hazil Sur, for example, generally did not take parrots (Psittacidae) or doves (Columbidae) for subsistence purposes, but these taxa occur at X-Hazil Sur and are widely hunted throughout the Neotropics. Parrots and doves at X-Hazil Sur, however, were killed as noxious animals when they fed on crops. That these species were present at X-Hazil Sur, but not harvested, could suggest that they were not acceptable to Maya hunters or that these kills were not reported during the study. More likely, however, the limited number of game species taken was sufficient to meet the subsistence needs of hunters.

When asked why certain wildlife species were harvested and others not harvested, hunters at X-Hazil Sur replied with a variety of responses, including: "too big" (e.g., tapir), "too small" (e.g., squirrel), "the meat doesn't taste good" (e.g., tayra and opossum), and "its not right to kill a harmless animal" (e.g., armadillo and monkeys). Taboos did not appear to explain any of these statements, and responses varied among hunters.

The availability of canned meat and domestic animals also will affect the number and variety of animals taken by hunters in at least two ways. One, hunters can depend on purchased meat to compensate for outings when no game is taken. This probably will reduce the number and variety of game taken as the hunter will not necessarily go hungry that day. Two, hunters can evaluate the cost and desirability of killing a wild animal versus purchasing meat. This also should reduce the number and variety of game taken by giving the hunter the choice on not taking relatively small or poor-tasting species. Given the availability of canned meat and domestic animals, and recognizing the low number of kills per hunter (ca. 7 per hunter during 17 months), subsistence hunting at X-Hazil Sur was quite opportunistic.

Sex and age class of game species. Information about the sex and age classes of game is important in evaluating hunter game preferences, the structure of local game populations, and the likelihood that one specific sex or age group might be more vulnerable than another group to hunters. These elements are important in evaluating game use by subsistence hunters.

At X-Hazil Sur, the proportions of male and female birds and mammals harvested by hunters differed. For mammals, more females were taken by hunters than males for all species except the brocket deer, while for birds, more males were taken by hunters than females for three of the four species (equal numbers of males and females taken for the ocellated turkey). Hunters at X-Hazil Sur attributed this to additional nutritional demands on female mammals while suckling their young and the consequent greater use of gardens to obtain food, not on any selection for females by hunters. Maya hunters also indicated that when feeding in gardens, females accompanied by their young were less vigilant than normal. This was especially true for female coatis and white-tailed deer, two species frequently taken in gardens when lactating. Male mammals, according to hunters, were less vulnerable than females to hunters for behavioral reasons; adult males tended to occur individually and could quickly and quietly escape, while adult females tended to occur in groups that included young and other females. Large groups with young, according to hunters, could not escape detection easily as the young frequently made loud noises as they foraged or attempted to flee hunters. Male birds, according to hunters, were easier to take than females because males often displayed from tree tops. While displaying, males were highly visible and less wary of hunters than they normally were. This suggested that female mammals and male birds were more frequently taken as a consequence of their behavior, including different habitat use patterns between sexes, and not as a result of active selection by hunters.

At X-Hazil Sur, birds and mammals exhibited similar patterns of take by age in that adults composed > 70% of the harvest although young and subadults also were taken. For mammals, substantial numbers of subadults also were taken (ca. 28%), but few subadult birds were taken (ca. 17%). Hunters at X-Hazil Sur offered no explanation about these differences other than to suggest that birds matured faster than mammals. It was clear, however, that game of any age class, regardless of species, was potential prey for hunters.

Only a few studies have documented the age or sex of game taken by subsistence hunters. Age and sex are summarized, however, for three studies in lowland Peru. Pacheco (1987) showed that for both mammals and birds, slightly more females than males were taken by forestry technicians conducting a tree survey, but the study was short (13 days) and sample sizes small (14 species, $\underline{n}$ = 46 game animals). At the second site, Alvard and Kaplan (1991) reported that adults composed 57% of the pacas taken, 83% of the brocket deer, and 74-76% of the peccaries. At the third site, Bodmer (in litt.) reported that males were more frequently taken than females for the collared peccary (1:0.66, males:females, $\underline{n}$ = 164 individuals), grey brocket deer (*Mazama gouazoubira*, 1:0.75, $\underline{n}$ = 28), and paca (1:0.57, $\underline{n}$ = 174), while females were more frequently taken than males for the white-lipped peccary (1:1.10, $\underline{n}$ = 166), red brocket deer (1:1.31, $\underline{n}$ = 60), agouti (1:1.31, $\underline{n}$ = 97), and acouchi

(*Myoprocta* spp., 1:1.17, n = 13), while take by sex was equal for the capybara (*Hydrochaeris hydrochaeris,* 1:1.00, n = 10). For Valley Bisa hunters pursuing large mammals in Zambia, Marks (1973) reported that hunters took more males than females (47 vs. 32 individuals) and more adults than subadults and young (79 vs. 11 individuals). As additional studies are completed, they likely will show differences in rate of take by age and sex between species taken by subsistence hunters.

Reproductive condition. Information on the reproductive condition of game is important in assessing the impact of any hunter selection for particular age and sex classes of game (Redford and Robinson, 1990). If gravid, lactating, or brooding females are taken by hunters, then an evaluation of the total harvest must also consider the young that will die.

At X-Hazil Sur, hunters harvested female mammals regardless of their reproductive condition. While most female mammals were not gravid or lactating, three species had relatively large proportions of females that were pregnant or caring for young: paca (40% gravid or lactating), agouti (32%), and white-tailed deer (32%; Figure 3-1). These species were among the main game species by number of individuals and total body mass (Table 3-1).

Due to small sample sizes, it was not possible to assess the reproductive condition of female game birds. The lack of developing eggs or a brood patch suggest that gravid or brooding females rarely were taken by hunters.

Little has been written about the reproductive condition of game animals taken by hunters in the Neotropics. In Mexico, Lazcano-Barrero et al. (1988) reported that reptiles, especially turtles and crocodiles, frequently are taken while guarding their nest. Also in Mexico, Santana et al. (1990) reported that subsistence hunters at the Sierra de Manantlán Biosphere Reserve refrained from hunting during specific periods of time in order to avoid harvesting pregnant or nursing birds and mammals. For lowland Peru, Bodmer (1989) reported that reproductively active ungulates frequently were harvested by hunters, as follows; collared peccary (41% females taken were reproductively active), white-lipped peccary (62%), red brocket deer (40%), grey brocket deer (*Mazama gouazoubira*; 33%), and lowland tapir (*Tapirus terrestris*; 37%). Most likely subsistence hunters throughout the Neotropics take substantial numbers of gravid, lactating, or brooding females, but until further studies are conducted the impact of this hunting on game populations cannot be assessed.

Distribution of take by month. Seasonality data, when combined with information about the age and sex composition of harvested game can be used to determine whether different age or reproductive classes of game are more susceptible to hunting at certain seasons (Redford and Robinson, 1990). Harvest of game animals varied during the year following a regular pattern that was recognized by hunters at X-Hazil Sur. According to hunters, each species had a time during the year when it was more likely to be taken. The factors that influenced the timing of this period were different for each species, but according to hunters included: season (dry vs. wet), garden cycle, mating period, fruit and seed availability in the forest, and activities by people (e.g., *chicle* tapping, selective logging, and clearing new garden sites).

For mammals, the harvest of brocket and white-tailed deer occurred primarily in areas categorized as Plots & Gardens and took place during the early wet season (June-July), just after crop seeds planted in the garden began to sprout. Deer also were taken during September-October. According to hunters, this was the rutting season and deer were less vigilant than normal. Coatis were harvested during the late wet season and early dry season. Beginning in September, during the late wet season, coatis were taken by hunters as they entered gardens to feed on corn, and beginning in January, during the early dry season, they were harvested as they entered areas being cleared as new gardens. The harvest of pacas and agoutis also took place during the dry season and was associated with the harvest of corn and clearing new gardens. Hunters often took coatis, agoutis, and pacas while logging or tapping sapodilla trees. Pocket gopher harvest took place during both seasons as hunters worked in their gardens. The harvest of collared peccaries was atypical of game mammals in that take occurred throughout the year.

Gravid female mammals were taken throughout the year. The monthly distribution of pregnancies suggested that game mammals had two reproductive patterns (Figure 3-5). In the first group, species reproduced throughout the year. This group was composed of the agouti, paca, and collared peccary. In the second group, species reproduced during discrete periods. For all mammals combined, the highest frequency of gravid females occurred during January-April 1990, during the dry season (see Figure 2-4).

For birds, the most obvious seasonality of take was for the great curassow and the ocellated turkey. These two species primarily were taken during the early dry season. According to hunters, great curassows and ocellated turkeys seemed to be more active at this time as it was their mating period.

Due to small sample sizes and the limited period over which bird data were recorded, it was difficult to assess monthly differences in the reproductive condition of birds. Eggs were reported only for the thicket tinamou (May 1990) and the plain chachalaca (January, April, and May 1990; Figure 3-6). This period corresponded with the dry season.

Seasonal differences in the composition of harvested game harvest have been reported for several long-term studies. For Barí Indians in Colombia, for example, Beckerman (1980) noted differences between months in the composition of mammalian prey taken. Each of the nine families of mammals taken during that study dominated hunter inventories for 1-3 months. During some months, no mammalian prey were taken, while in others, prey from two or three families were taken. Smith (1976) and Yost and Kelley (1983) noted a similar seasonal variation in number of animals killed for Brazil and Ecuador, respectively. These differences were attributed to several factors, including fruit availability to game animals and the need by hunters to plant or harvest a garden. These were some of the same factors mentioned by Maya hunters at X-Hazil Sur to explain monthly differences in the composition of the game harvest.

Distribution of take by time of day. Behavioral studies suggest that species are primarily either diurnal, nocturnal, or crepuscular. This pattern of discrete activity periods for game was not observed in Ejido X-Hazil y Anexos as indicated by the broad range of time over which individuals of each species were taken. Eleven of the 12 game species were taken during the day as well as during the night or at dawn/dusk. The white-lipped peccary, however, was taken only during the day, but this likely was due to a small sample size (three individuals killed during a single outing).

There are at least two possible explanations for this broad temporal pattern of take. One, game species in the study area may have expanded their activity periods since hunters were active throughout the day and night. Many game species in other areas are known to change their behavior during the hunting season. For example, ducks, geese, and white-tailed deer hunted on refuges and wildlife management areas in the United States are known to limit their activity until after the daily hunting period has ended. Two, the pattern of take may not reflect the species' activity period if the animal was shot while inactive or if disturbed while inactive and killed while attempting to escape. Hunters in Ejido X-Hazil y Anexos may have disturbed resting animals while enroute to logging or *chicle* tapping sites or when they used headlamps and dogs to locate roosting birds and or game hidden in caves or dens. These explanations suggested that the pattern of take did not reflect the activity patterns of the species, but instead reflected the activity period of hunters.

Characteristics of the Hunters and their Weapons

Age and identification of hunters. Among indigenous peoples in the Neotropics, subsistence hunting generally is practiced by all of the adult males of the community (cf., Stearman, 1989, 1990; Vickers, 1983, 1984, 1988). With limited exceptions (e.g., Aché in Paraguay [Hurtado et al., 1985]; Matses in Peru [Romanoff, 1984]), women do not participate in hunting (i.e., kill game or carry weapons). While 84 of 86 hunters at X-Hazil Sur were males, only about a third of the adult males reported taking game. Conversations with village residents suggested that most of the remaining two-thirds of the male villagers did not hunt, but this was not confirmed. Among the reasons offered by nonhunters for not hunting, especially by young men, were that they didn't have a gun; didn't know how to track or identify game sign; or didn't like the insects, rain, or late hours associated with hunting.

The age class distribution of known hunters at X-Hazil Sur (79% were 15-39 y old) compared with the age class distribution of all men (40% were 15-39 y old) suggested that the population of hunters was aging and that older hunters were not being replaced by younger hunters. This may seem counter-intuitive in view of the relatively young ages of the seven main hunters (see Appendix E), but conversations with both older and younger hunters indicated that few young men were interested in becoming serious hunters. The skills associated with hunting are acquired by young men over several years when they learn how to use a gun, interpret game sign, and develop the self confidence to pursue game while alone in distant parts of the *ejido*. Many young Maya men no longer are interested in developing these skills. This follows a recent trend among young Maya in the area to attend outside technical and secondary schools, and to seek employment in nearby towns, instead of remaining in the village and learning traditional subsistence activities.

The number of kills per hunter and the amount of game harvested per hunter indicated that hunters at X-Hazil Sur did not take similar numbers of game. At X-Hazil Sur, the seven main hunters (8% of hunters) took 54% of the game by number and 40% by weight. This disproportionate harvest by a few hunters was similar to that reported for other indigenous groups in the Neotropics. For example, Hames (1979) reported that among the Ye'kwana in southern Venezuela, 36% of the hunters took 75% of the game by weight, while among the Yanomamo, 50% of the hunters took 85% of the game. For the Yuquí in Bolivia, Stearman (1990) reported that 25% of the hunters took 61% of the game by weight in 1983 and 32% of the hunters took 75% of the game by weight in 1988. Maya hunters were different from other subsistence hunters, however, in at least one regard. At X-Hazil Sur, 47 of 86 hunters took only one or two game animals during the study, while subsistence hunters described in other studies regularly undertook outings and obtained game. The reason for this difference probably is the number of domestic animals and opportunity to engage in wage labor available to Maya hunters. Given the availability of canned meat and domestic animals, and recognizing the low number of kills per hunter (ca. 7 per hunter during 17 months), subsistence hunting at X-Hazil Sur was quite opportunistic.

Hunter group size. The number of hunters participating in a hunting outing varies somewhat according to the type of hunt and the cultural background of the people, but hunter group size can be generalized across the Neotropics. At X-Hazil Sur, small-sized groups of hunters were common, while large groups were infrequent. About 85% of the 419 outings were conducted by groups containing one or two hunters, who divided the game among themselves. This followed the general pattern at X-Hazil Sur of adult men working alone or with a single partner and sharing part of the harvest or earnings. Large hunting groups at X-Hazil Sur usually were organized at the community level to obtain game for a specific religious occasion. On these outings, participants offered information about recent game sightings or tracks to others in the group, and the hunter making the kill generally donated the game to the feast organizers. These results indicated that hunter group size at X-Hazil Sur closely followed the pattern of few large groups and numerous small groups exhibited by other subsistence hunters in the Neotropics.

The average number of game animals harvested per outing, at X-Hazil Sur, regardless of hunter group size, was relatively low (1.00 - 1.81 animals/outing). This indicated that the harvest of one or two game animals per outing was acceptable to hunters.

Among the highly traditional Yekuana Indians in Venezuela (Sponsel, 1986), most hunting outings were conducted by one or two hunters. Group hunts were organized only when tracks of large-sized prey (e.g., deer and tapir) were located. Among the traditional Waorani Indians in Ecuador (Yost and Kelley, 1983), 63% of the outings were conducted by individuals, while groups of three or more hunters conducted only 10% of the outings. In northern Brazil (Saffirio and Scaglion, 1982), hunting group size varied between Yanomami Indian groups. For traditional Yanomami hunters, individual hunters conducted 78% of the outings, groups of two conducted 21% of the outings, and three or more hunters conducted only 1% of the outings. For acculturated Yanomami hunters, however, individual hunters conducted 9% of the outings and groups of two conducted 73% of the outings, while groups of three or more conducted 18% of the outings. Saffirio and Scaglion (1982) attributed these differences among the Yanomamo in part to the scarcity of game along the highway in the area used by the acculturated hunters. In eastern Brazil (Smith, 1976), individual mestizo hunters conducted 76% of the outings, while two or more hunters conducted 24% of the outings among three communities of settlers along the Transamazon Highway. These studies suggested that among settlers as well as traditional and acculturated indigenous peoples in the Neotropics, the vast majority of hunting outings were conducted by individual hunters or pairs of hunters.

Types of weapons. The type of weapons used by hunters will affect the size, amount, and type of game harvested. Hunters at X-Hazil Sur used traps, rifles, and shotguns to harvest game. Traps were used for 9% by individuals of the game taken (mean prey weight = 0.6 kg). Rifles were used for 39% of the game (mean prey weight = 1.8 kg). Shotguns were used for 42% of the game (mean prey weight = 5.9-21.4 kg). In general, traps and rifles were used for smaller prey and shotguns were used for larger prey. However, 22 caliber rifles were used to kill prey up to the size of a brocket deer (mean weight = 15.6 kg), while 12 gauge shotguns were used to kill prey as small as the great curassow (mean weight = 3.1 kg). This indicated that Maya hunters did not follow a strict rule about using more powerful weapons for larger game and less powerful weapons for smaller game.

When questioned about how they selected the weapon to use for a particular prey item, Maya hunters usually laughed and responded that they only had a single, very old gun from which to choose. Further, hunters often could not know what size prey they would encounter during a hunting outing and thus could not select one weapon over another. Thus, for most hunters at X-Hazil Sur, the only question was whether their weapon could kill the prey item at hand.

The best explanation about how hunters select their weapons may deal less with preferences and more with what types of weapons are readily available. Hunters at X-Hazil Sur reported that due to Mexican legislation the only nearby location to purchase weapons or ammunition was at Mérida, about 250 km away. At Mérida, State of Yucatán, licensed dealers offered a limited selection of items to buyers with the necessary permits. Hunters at X-Hazil Sur indicated that 22 caliber rifles and 16 and 20 gauge shotguns were best for hunting and most easily obtained, but it is also possible that sales of 12 gauge shotguns and larger caliber rifles were restricted by the Government of Mexico. Whatever the reason, 22 caliber rifles and 16 and 20 gauge shotguns and the corresponding ammunition were more easily obtained than 12 gauge shotguns and larger caliber rifles.

Among indigenous people in the Neotropics, shotguns, blowguns, and spears are widely used to harvest game (Hames, 1979; Hill and Hawkes, 1983; Yost and Kelley, 1983). While contemporary Maya Indians in the Mexican state of Chiapas mainly use rifles and shotguns (March M., 1987), archeological studies and descriptions of Maya hunters at the time of the conquest suggested the that pre-historic Maya used a broad array of weapons including dogs, blowguns, spears, atlatls, bows and arrows, snares, traps, torches, whistles, nets, and slingshots to attract and kill game (Flores, 1984; Hamblin, 1984, 1985; March M., 1987; Pohl, 1976).

The type of weapon used will have a direct impact on the type of game taken by hunters. At X-Hazil Sur, whereas hunters generally did not use a specific type of weapon to take a specific type of game, shotguns generally were used to take the heaviest prey (e.g., deer and peccaries) and rifles and traps were used to take the lightest prey (e.g., pocket gophers and thicket tinamous; Figure 3-10). These results differ somewhat from those presented in two studies of tribal peoples in South America. Hames (1979) compared the efficiencies of the shotgun and the bow in Neotropical forest hunting by the Ye'kwana and Yanomamo Indians along the upper Orinoco River in Venezuela. Hames (1979) noted several differences between the two types of weapons (for example, mean prey weight and number of individuals taken), but the most significant difference between the two types of weapons, according to Hames, is the larger number of arboreal and volant animals killed by the Ye'kwana (shotgun) hunters compared with the Yanomamo (bow) hunters. The arboreal and volant animals taken by the Ye'kwana included birds (especially taxa in the Cracidae Family), monkeys (especially taxa in the Cebidae Family), sloths (*Bradypus tridactylus*), and collared anteaters (*Tamandua tetradactyla*). In the second study, Yost and Kelley (1983) compared the efficiency of shotguns, blowguns, and spears in forest hunting by the Waorani Indians in eastern Ecuador. Yost and Kelley (1983) determined that 36% by weight of the prey was taken with blowguns, 51% with shotguns, and 13% with spears. Blowguns were used almost exclusively for arboreal animals under 10 kg, the spear was used for large mammals, and the shotgun was used for both classes of animals. These two studies show that tribal hunters generally consider the type of prey at hand when selecting the type of weapon to be used. Maya hunters, however, appear to be less concerned about prey type than are tribal hunters when selecting the type of weapon to be used.

Characteristics of the Hunt

Several techniques have been described for human hunters in the Neotropics. For example, the Aché Indians conducted day hunts through the forest, walking about 15 km on an average outing (Hill and Hawkes, 1983). Matses Indians in the Peruvian Amazon conducted day hunts, but also undertook extended trips lasting several days and conducted at great distances from their village (Romanoff, 1984). In Colombia, the Maracá Indians hunted at night; undertook day-long trips as well as extended hunting expeditions lasting several weeks; and constructed and used a number of special hunting aids, including blinds, stands, and deadfalls (Ruddle, 1970). Settlers and colonists in eastern Brazil used dogs and flashlights, pursued game during the day, waited in stands for game during the evening, and patiently waited along garden edges or near fruiting palms (*Orbygnia martiana*; Smith, 1976). The variety of these techniques indicated that game could be successfully taken by various methods.

Hunting outings. Maya hunters at X-Hazil Sur used several techniques to obtain game. The most frequently used technique was to track/stalk game (79% of 419 outings). About 82% of the game, by individual, was taken by this method. Game also was taken by traps (10% of outings) and while hunters were positioned in stands/platforms (8% of outings). The average hunter group size for these three techniques was 1.6-1.8 hunters/outing, while the average quantity of game harvested was 1.2-1.4 individuals/outing.

Hunters reported that they used the different techniques under different circumstances. Tracking/stalking was used primarily during the day and occurred in both gardens and forested areas. Usually an outing of this type was undertaken only after a hunter, based on the type of tracks or feeding sign made by the animal, had ascertained over several days the species and general behavior of the prey. Game was tracked throughout the year, but was less frequently so during the height of the dry season, according to hunters, when noise from dry leaves and ground litter could alert the game.

Stands and platforms were used primarily as sites from which to kill animals at night while they were feeding in gardens or on fallen fruit in the forest. Deer (during April-July) and pacas (during December-March) were especially vulnerable to this technique. Usually stands and platforms were constructed on an elevated location in the garden or at a location with a clear view of the game trail and the fallen fruit. Stands and platforms also were constructed at waterholes and at the entrances of caves used by pacas and agoutis.

Traps were used primarily to capture pocket gophers, but pacas and agoutis also were taken. Normally, traps were set in gardens where the hunter was working or along trails enroute to the work site. Traps usually were checked twice a day while the hunter was in the area. According to hunters, traps were inefficient as they often misfired, the prey often escaped, other hunters frequently stole the game, or the hunter forgot the location of the trap.

When compared with other subsistence hunters, the Maya should be considered as indigenous peasants and not as indigenous hunters. Maya hunters at X-Hazil Sur were quite similar to Brazilian settlers and colonists with respect to the techniques used in that both groups used dogs, tracked/stalked game, hunted by day and by night, and constructed stands/platforms. The Maya at X-Hazil Sur were unlike most of the more traditional indigenous people in the Neotropics, however, in that the Maya usually did not hunt in village groups, undertake extended expeditions, or even use blowguns or bows and arrows as weapons.

Kill site locations and vegetation types. The vegetation types of game kill sites can be invaluable in interpreting human hunting patterns as well as patterns of habitat use by game (Redford and Robinson, 1990). Hunters do not just randomly undertake a hunting. Rather, the timing and location of hunting outings takes into account game behavior and feeding patterns on fruiting trees or crops in gardens.

At X-Hazil Sur, the distribution of kill sites suggested that game species generally were taken in all major vegetation types. Rather than using a single vegetation type, the harvested game used highly-disturbed and early-successional vegetation types (e.g., Plots & Gardens and Early Secondary Forest) as well as little-disturbed and late-successional vegetation types (i.e., Late Secondary Forest; Table 3-7; Appendix G). Nine of the 12 game species used three of the vegetation types; Plots & Gardens, Early Secondary Forest, and Late Secondary Forest. Except for the white-lipped peccary (n = 3; 100.0% of locations in Late Secondary Forest), no species were taken exclusively in a single vegetation type. According to hunters, the reason for the wide variety of vegetation types in which game species were taken was due to the fact that game species used different vegetation types for different activities, for example, to rest, mate, forage, or seek drinking water.

The significant relationship between game kill sites and areas categorized as Plots & Gardens, Early Secondary Forest, and Other was supported by results from two other studies (Table 3-10). At X-Hazil Sur, 63% of mammals and 70% of birds, by number of individuals, were taken in these three vegetation types although these types composed only 11.5% of the study area (see Table 2-1). In Brazil, Ka'apor Indian hunters at one site harvested 14.7% by number of the total game in areas categorized as gardens (0.3% of the total catchment area), while hunters at another site harvested 36.6% by number of the total game in gardens (1.7% of the total catchment area; Balée, 1985). Balée suggested that game used gardens as refuge and foraging areas. In Ecuador, Runa Indian hunters harvested about 45% by number of the pacas and agoutis taken in areas categorized as fallows and gardens (Irvine, 1987). Fallows and gardens also were important game kill sites for the collared peccary (14.3% by number), brocket deer (35.0%), and acouchi (*Myoprocta pratti*; 28.9%) taken by the Runa. Irvine suggested that gardens and fallows were important to pacas and agoutis due to the crops, while fruiting trees attracted game in the fallows.

Minimum catchment area and mean kill site distances. An understanding of the catchment area over which hunters range is important in evaluating harvest yields and the status of game populations in the area (Redford and Robinson, 1990). On a broader scale, this information can be used to analyze human territoriality and resource use at a community level (Vickers, 1983).

The minimum catchment area for hunters at X-Hazil Sur was about 370 km^2, but hunters from this village as well as from Uh-May and Chancah Veracruz (not studied) ranged throughout the *ejido* (552.95 km^2). This catchment area of 370 km^2 may be somewhat artificial for two reasons: One, the eastern boundary of the *ejido* roughly extends to the savanna on Sian Ka'an Biosphere Reserve. The savanna is flooded much of the year, due to rainfall, and hunting is difficult (see Figure 2-4). Two, the *ejido* boundary is clearly marked. *Ejido* residents avoid legal problems by not entering the adjacent *ejido* to hunt, plant gardens, or harvest timber.

Catchment area values reported for mestizos and indigenous groups indicated that while some communities did kill some game over relatively large areas during the time of the studies, most use much smaller areas (Table 3-11). For example, among the largest catchment areas reported for an indigenous group were a region of about 1810 km^2 used by a community of 500 Matsés Indians in western Brazil (Romanoff, 1976) and a zone of about 600 km^2 used by a group of 155 Aché Indians in eastern Paraguay (Hill and Hawkes, 1983). The reported catchment areas for eight other indigenous groups ranged from 79 to ca. 400 km^2. Among mestizos, the reported catchment area was 100-500 km^2 per community. While these areas and hunter groups differed, for example, with respect to vegetation type, use of weapons, wildlife populations, degree of acculturation, human population density, and importance of fishing and shifting cultivation, the catchment areas--excluding the extremely large and small areas--were remarkably similar in size at 200-600 km^2.

The relationship between catchment area and specific harvest areas around communities of indigenous and mestizo subsistence hunters are poorly known. At X-Hazil Sur, harvest areas in which individual species were taken ranged from 4.8 km^2 to 251.8 km^2 and were substantially less than the total area available on the *ejido* (Table 3-8). Only two species were taken over relatively large areas: coati (251.8 km^2) and collared peccary (211.5 km^2). Both coatis and collared peccaries are known to be highly mobile and occur in groups, but their home range sizes in Mesoamerica are poorly known.

Mean kill site distances varied between species and ranged from 3.4 km (pocket gopher) to 7.6 km (ocellated turkey; Table 3-8). According to hunters at X-Hazil Sur, the ocellated turkey and great curassow (7.5 km) were quite wary and easily disturbed by people. These observations agreed with those from other sites where researchers reported that the ocellated turkey and great curassow were highly sensitive to human disturbances.

Two possible explanations may account for the limited harvest areas in which individual game species were taken: One, individual species did not occur except in those areas where they were harvested. Two, individual game species occurred beyond the catchment area, but were not harvested by hunters in those locations. Comments offered by hunters and wildlife census data presented in Chapter 4 supported the second possible explanation. According to several hunters, it was easier to locate and hunt game nearby, in the vicinity of a garden or at a work site, than it was to track or stalk game in distant areas that were poorly known by the hunter. A consequence of this belief was that hunters may have harvested less game.

Kill site distances also suggested that many species were highly tolerant of human disturbances. Of the 11 species for which a range could be calculated, nine game species had a minimum kill site distance $<$ 1.4 km (Table 3-8). At this distance from the village, children frequently played, human voices and barking dogs often could be heard, street lights were easily seen at night, and dogs and men frequently passed enroute to the gardens (see Chapter 6). Apparently these kinds of disturbances were insufficient to cause most game species to avoid the area around the village.

The minimum catchment area and mean kill site distances for individual subsistence hunters in the Neotropics, as compared with areas used by the village as a whole, are poorly known. For Maya hunters at X-Hazil Sur, the minimum catchment areas for the seven main hunters ranged from 7.2 km^2 (# 62) to 68.1 km^2 (# 9; Table 3-9; Appendix E). Hunter # 62 (23 y old) had the smallest catchment area and reported that he only hunted in the vicinity of his garden, which was near X-Hazil Sur, and at nearby *chicle* tapping sites. Hunter # 9 (21 y old) had the largest catchment area. Although this

Table 3-10. Percent frequency of game kill sites in forests vs. fallows/gardens in Brazil (Ka'apor Indians; Balée, 1985) and Ecuador (Runa Indians; Irvine, 1987).

	Balée									Irvine		
	Site 1 (29 June-19 August 1981)			Site 2 (4 November-26 November 1981)			Site 2 (12 January-4 February 1982)			San José (February 1982-April 1984)		
Game species	% Inds. forest	% Inds. garden	n	% Inds. forest	% Inds. garden	n	% Inds. forest	% Inds. garden	n	% Inds. forest	% Inds. fallow & garden	n
a) Mammals												
Paca	55.6	44.4	18	100.0		2	50.0	50.0	2	57.5	42.5	106
Agouti[a]	78.8	21.2	33	75.0	25.0	4	85.7	14.3	7	51.8	48.2	114
Coati			0			0	100.0		2			0
White-lipped peccary			0			0			0			0
Collared peccary	100.0		1	100.0		3	64.3	35.7	14	85.7	14.3	35
Brocket deer[b]	100.0		3	66.7	33.3	3	33.3	66.7	6	65.0	35.0	20
White-tailed deer			0			0			0			0
Other mammals	72.4	27.6	21	87.5	12.5	8	75.0	25.0	4	71.1	28.9	204
b) All birds	94.4	5.6	18	100.0		1			0			0
c) All reptiles	100.0		61	100.0		11	100.0		29			0

[a] *Dasyprocta* spp.
[b] *Mazama* spp.

Table 3-11. Catchment areas for various mestizo and indigenous groups in the Neotropics (arranged by size of catchment area).

Group	Country	Local human population size (no. inds.)	Catchment area (km^2)[a]	Source
Matsés	Brazil	500	1810	Romanoff (1976)
Aché	Paraguay	155	600	Hill and Hawkes (1983)
Mestizos	Peru	310	500	Bodmer et al. (1988)
Yekuana	Venezuela	"Several hundred"	ca. 400	Sponsel (1986)
Maya	Mexico	ca. 1000	370	This study
Yuquí	Bolivia	96	314	Stearman (1990)
Waorani	Ecuador	230 (4 villages)	ca. 300	Yost and Kelley (1983)
Mestizos	Brazil	638	250	Ayres and Ayres (1979)
Siona-Secoya	Ecuador	297	225	Vickers (1983)
Irapa-Yukpa	Venezuela	540	200	Paolisso and Sackett (1985)
Mestizos	Brazil	734 (3 villages: 351, 179, & 204)	100 each	Smith (1976)
Ka'apor	Brazil	99 (2 villages: 27 & 72)	79	Balée (1985)
Yanomamo & Ye'kwana	Venezuela	127 (3 villages: 76, 35, & 16)		Hames (1980)

[a] Catchment areas for all studies except the present study were approximated in one of two ways: One, by using the average or maximum hunting distance from the village as the radius of a circle (the "catchment area") that encompassed the village. This method assumed that outings occurred in all directions from the village. Two, estimating the area used for hunting outings according to known landmarks and boundaries, such as rivers. Both methods likely overestimated the true catchment area. The method used for the present study was based on careful measurements of the area encompassed by the actual kill sites.

individual did not plant a garden, he did engage in wage labor at widely scattered sites on the *ejido*. This hunter reported that he frequently killed game near the village and while at or enroute to the work sites. All seven main hunters reported that the areas in which they pursued game included a variety of regions with which they were familiar, including gardens, fallow fields, and present or former work sites. No hunter reported using essentially the entire *ejido* as a catchment area.

Use of dogs. The ability of dogs to locate and kill game can have a tremendous impact on the type and amount of game harvested by subsistence hunters. Dog use, however, is quite variable among subsistence hunters in the Neotropics. For example, the Aché Indians in Paraguay, did not use dogs until recently (Hill and Hawkes, 1983). On the other hand, the Irapa-Yukpa in western Venezuela have used highly trained dogs for many years (Paolisso and Sackett, 1985). In many indigenous groups, however, including the Bayano Cuna Indians in Panama (Bennett, 1962), Yanomamo Indians in Brazil (Saffirio and Scaglion, 1982), Tatuyo Indians in Colombia (Dufour, 1981), and settlers and colonists in eastern Brazil (Smith, 1976), untrained dogs accompany hunters and locate and kill prey.

At X-Hazil Sur, dogs accompanied hunters on 17% of the outings and assisted in taking at least 127 game animals (22% of total). The coati was especially vulnerable to dogs. Only two Maya hunters reported that they provided any special feeding or training to their dogs. In this regard, the use and care of dogs by Maya hunters at X-Hazil Sur was about the same as that by most other groups of subsistence hunters in the Neotropics.

Comparison of Cerro Brujo and Ejido X-Hazil y Anexos Game Harvest

A comparison between these two sites of the game taken indicates that hunters harvested terrestrial mammals in different proportions. At Cerro Brujo, the proportion, by percent biomass, of agoutis, pacas, armadillos, opossums, and rats harvested was substantially higher than at Ejido X-Hazil y Anexos (Table 3-12). At Ejido X-Hazil y Anexos, the proportion of brocket deer and other (pocket gophers and coatis) was substantially higher than the biomass proportions harvested at Cerro Brujo. The percent biomass of collared peccaries, white-tailed deer, and white-lipped peccaries were about equal at the two sites.

Table 3-12. Comparison of the biomasses of the Cerro Brujo mammals with the biomasses for the same species at Ejido X-Hazil y Anexos.

	Cerro Brujo mammal collection				X-Hazil Sur hunting inventory			
Species	Minimum number of individuals	Percent of total individuals	Biomass (kg)	Percent of biomass	Total individuals	Percent of total individuals	Biomass (kg)[1]	Percent of biomass
Agouti	204	43.8	408	14.24	35	9.1	96.8	3.77
Paca	104	22.3	832	29.04	47	12.2	274.8	1.07
Armadillo	69	14.8	276	9.63	0	0	0	0
Collared peccary	27	5.8	621	21.68	40	10.4	618.5	2.41
White-tailed deer	14	3.0	560	19.55	24	6.2	709.0	2.76
White-lipped peccary	4	0.9	132	4.61	3	0.8	94.3	3.67
Brocket deer	2	0.4	30	1.05	16	4.2	250.0	9.72
Opossum	1	0.2	1.8	---	0	0	0	0
Rats[2]	27	5.8	3.0	---	0	0	0	0
Other[3]	14	3.0	---	---	220	57.1	527.2	20.51
Total	466	100.0	2864		385	100.0	2570.6	100.0

[1] Biomass based on 377 individuals (see Table 3-1).
[2] *Sigmodon*, *Oryzomys*, and *Hopolomys*.
[3] At Ejido X-Hazil y Anexos, this category was composed of pocket gophers and coatis, whereas at Cerro Brujo, it was composed of woolly (*Caluromys*) and mouse opossums (*Marmosa*).

There are several possible explanations for these differences in the relative proportions by biomass at which game were harvested at these two sites. One, the population densities of the game species may be different (cf., Glanz, 1990, 1991). At Cerro Brujo, agoutis (43.8% of individuals taken by hunters), pacas (22.3%), and armadillos (14.8%) comprised 60.8% of the mammals taken. Coatis and pocket gophers were not taken. At Ejido X-Hazil y Anexos, coatis and pocket gophers composed 57.1% of the mammals harvested. This possibility will be discussed further in Chapter 4.

Other possibilities regarding why game harvest differed between sites include behavioral differences by game or hunters. While game and hunter behavior were not examined in this study, it is interesting to note that by percent biomass of harvested game, the harvest of large mammals was similar between sites, but the harvest of small and medium-sized mammals was proportionally greater at Cerro Brujo. This suggests that hunters at Ejido X-Hazil y Anexos may be selecting for the larger mammals. The reason for the relatively large proportion of pocket gophers and coatis taken by Maya hunters, compared with Cerro Brujo hunters, however, is unclear.

Sustainability of Maya Hunting

It is important to note that many of the species reported by Linares (1976) for Panama still are widely hunted in peasants and indigenous people in Mesoamerica, including Maya subsistence hunters in Quintana Roo, Mexico. Of the 13 game species indicated by Linares (1976:339), all except the rats. opossums, and manatee (*Trichechus manatus*) are taken today by Maya hunters. Whereas the manatee does not occur on the study area, the rats and opossums are present (Navarro L. et al., 1990), but not consumed. Given the length of Maya occupation in the area and the extent of their subsistence activities, it is important to understand how game species have continued to survive in this area but have become depleted in other areas subjected to hunting.

In conclusion, in this assessment of game harvest by Maya hunters in Quintana Roo, Mexico, I have shown that hunting still is practiced by many members of the community of X-Hazil Sur. This an important activity that now is opportunistic rather than obligatory in nature but still provides prestige and meat to the hunter and his family. The key to the sustainability of hunting appears to be the moderate levels of disturbance caused by shifting cultivation. The gardens themselves and the native plants that generate from the seed bank in the soil below the gardens provide ample food resources for the game (see Chapters 5 and 6). If *milpa* agriculture is replaced by cattle ranching and commercial logging, the delicate balance developed over millennia between game and gardeners likely will be broken. If the levels of gardening and subsistence continue at present rates at Ejido X-Hazil y Anexos, however, most game species will probably continue to exist in the area.

CHAPTER 4
WILDLIFE DENSITIES IN SUCCESSIONAL FORESTS
AROUND A MAYA VILLAGE IN QUINTANA ROO, MEXICO

Introduction

Anthropologists, ecologists, and wildlife biologists have commented widely on the impact of shifting cultivation on wildlife populations in the Neotropics and the habitats in which the wildlife occurs (cf., Redford and Robinson, 1987; Robinson and Redford, 1991a; Vickers, 1988). While some researchers have considered shifting cultivation as being destructive of natural habitats and the wildlife populations that depend on undisturbed conditions, other researchers have noted that many wildlife species do in fact occur in large numbers in areas used by humans for horticultural purposes and may obtain some benefits from these areas. Rather than documenting the widespread depletion of game and natural vegetation, recent studies on the use of tropical rainforests by native Amazonians and prehistoric indigenous people in Panama, for example, have suggested that the swiddens and fallows of these people may be more complex than expected, and that the dichotomy between natural and managed forests may not be as well-defined as previously thought (Dufour, 1990; Irvine, 1987; Linares, 1976). Given the antiquity of these horticultural systems and the long-term uses of the associated flora and fauna by these people, including subsistence hunting, under certain conditions shifting cultivation and wildlife populations may be compatible.

Hunting is an integral component of the subsistence pattern of native Amazonians (Balée and Gély, 1989). Subsistence hunting, however, is not an independent activity. Rather, it has been proposed that the game taken by hunting is in part supported by shifting cultivation. Two field studies and one theoretical paper have examined the impact of shifting cultivation on wildlife abundance and subsistence hunting by indigenous peoples. One of the first studies to suggest a relationship between wildlife abundance and shifting cultivation was that of Linares (1976). Based on an archaeological study of the number and kinds of game encountered at Cerro Brujo, Panama, Linares (1976) proposed that the biomass of a small, select group of terrestrial mammals appeared to have been greater when they occurred in the vicinity of gardens and consumed garden crops than the biomass of these same species in areas that had not been disturbed by human practicing of shifting cultivation. The evidence suggests, according to Linares, that the collared peccary (*Tayassu tajacu*), agouti (*Dasyprocta punctata*), paca (*Agouti paca*), and white-tailed deer (*Odocoileus virginianus*) were hunted by prehistoric Cerro Brujo people in numbers disproportionately high to the biomass of these animals in natural conditions. To explain this, Linares made two deductions: first, the game species at Cerro Brujo fed on cultivated crops, and second, the abundance of gardens and game animals *vis a vis* each other was positively correlated. The occurrence of higher densities of game around gardens and the fact that these species consumed garden crops eventually resulted in a shift in hunting practices by the Cerro Brujo people. According to Linares (1976), the Cerro Brujo people shifted from tropical forest hunting (commonly practiced by tribal peoples throughout the Neotropics and characterized by a specific belief system, particular technology, and male-oriented trekking activities) to a new pattern called "garden hunting." It now appears that other indigenous peoples developed garden hunting as well as this practice has also been reported, for example, for the Bora Indians of Peru (Denevan et al., 1984).

According to Linares (1976), two types of game commonly were taken during garden hunting: one, smaller animals (e.g., paca and agouti) that lived in the underbrush or in burrows and two, larger animals (e.g., collared peccary and white-tailed deer) that were tolerant of humans or human activities and lived--or could live--in forest-edge conditions. Areas such as cultivated fields and house gardens were especially good areas in which these two kinds of game were taken. Shifting cultivation, Linares (1976) concluded, affects the biomass of terrestrial mammals that are behaviorally preadapted to being tolerant of human disturbances.

Whereas Linares (1976) described some of the ecological and behavioral characteristics of the game species taken by Cerro Brujo hunters in the vicinity of gardens, no direct physical evidence was presented to show that shifting cultivation affected the biomass of terrestrial mammals. In addition, new evidence now suggests that the reference points used to compare animal abundances may not be appropriate. Linares (1976) compared the relative abundance of mammals at Cerro Brujo, based on the identification of some 6,000 bones classified into 1,437 identifiable specimens belonging to 14 species. These identifications were converted to "minimum number of individuals" values for each species for a total number of 466 individuals taken by Cerro Brujo hunters over a 20 y period. Based on these 466 individuals, Linares (1976) compiled a hunting inventory based on number of individuals taken and their biomass. The relative proportions of the Cerro Brujo mammals, based on biomass, were compared with similar data for Surinam (biomass recalculated by Eisenberg and Thorington [1973] from Walsh and Gannon [1967]) and Barro Colorado Island (Panama; Eisenberg and Thorington [1973]). The comparison of these three sites showed that the percent biomass by species for the major taxa of terrestrial mammals at Surinam and Barro Colorado Island data were quite comparable. The percent biomass of these mammals, however, was quite different from that at Cerro Brujo. Linares (1976) concluded that the differences in faunal assemblages among sites were due to human hunters and shifting cultivation; Cerro Brujo was defined as having a "cultural faunal assemblage," whereas Surinam and Barro Colorado Island, due to a lack of hunters and gardens, were defined as having "natural" faunal assemblages. Based on recent research by Glanz (1990, 1991), it now appears, however, that mammal densities of many species at Barro Colorado Island are not natural, compared with other Neotropical sites. On one hand, 13 species of terrestrial mammals, including the jaguar (*Panthera onca*) and the white-lipped peccary (*Tayassu pecari*), are extinct or possibly extinct. In addition, densities for agoutis (*Dasyprocta punctata*), pacas (*Agouti paca*), sloths (*Bradypus* and *Choloepus*), and squirrels (*Sciurus*) are substantially higher than at other Neotropical sites. Glanz (1990, 1991) concluded that these relatively high population densities for some mammals were due primarily to the protected status of Barro Colorado Island and its protection from unregulated hunting.

The relationships between gardens and game abundance were further elucidated by Irvine (1987) in a two-phase study of resource management by the Runa Indians in the lowland tropical forests of the Ecuadorian Amazon. First, Irvine (1987) determined that the Runa Indians managed tree succession in some fallow areas by planting certain desirable species, especially fruit trees, and protecting other useful species. The managed and unmanaged fallows that resulted were strikingly different from each other in appearance and composition. Second, Irvine (1987) conducted a study of 833 game kills and determined that, when planted trees were in fruit, managed fallows were important capture sites for three caviomorph rodents (paca; agouti; and acouchi, *Myoprocta pratti*), numerically the most important game for the Runa. Irvine (1987) concluded that the Runa Indians had developed an efficient, resource-enhancement strategy. By managing fallow areas in the forest and by concentrating their hunting on the smaller, but numerically abundant caviomorph rodents (compared with the brocket deer [*Mazama* spp.] and the collared peccary that are larger, but less abundant), the Runa were in effect practicing garden hunting.

In a theoretical study unsupported by field data, Greenberg (1992) examined deer hunting by Maya Indians in the Yucatán Peninsula as an example of coevolution between humans practicing shifting cultivation and populations of this locally important game animal. When the peninsula was first settled, according to Greenberg (1992), the impact of the human population on the deer population was minimal as there were few people, little hunting, and limited shifting cultivation. Subsequently as the human population increased, the association between these two populations changed to one where humans practiced hunting and gathering, exploiting the small deer population at a low rate. Over time the association continued to evolve. Although hunting and gardening continued, the deer population increased because it had acquired a dietary preference for secondary vegetation that resulted from shifting cultivation. Deer, according to Greenberg (1992) also had a behavioral pre-adaptation that allowed for close contact with humans. Humans responded by hunting the more-abundant deer, but over time humans also increased in number and created more secondary vegetation favorable to deer. Given the primitive hunting technologies and the low human population density of the peninsula, this relationship, according to Greenberg (1992), explains the high harvest rate sustained by deer in the vicinity of Maya gardens.

The studies by Linares (1976), Irvine (1987), and Greenberg (1992) investigated gardens and hunting in lowland tropical forests where low densities of native peoples practiced shifting cultivation and subsistence hunting. They concluded that there was a pattern of increased hunting of game in areas where gardens had been planted. None of the studies, however, presented enough data to support the model of garden hunting. Specifically, none demonstrated that game animals ate crops or that game animals actually were more abundant around gardens than in forested areas. Without evidence that game animals consumed crops and were more abundant in the vicinity of gardens than in forest areas without gardens, the idea that deer and hunters coevolved through the practice of garden hunting is pure speculation.

In order to measure the effects of shifting cultivation and subsistence hunting on the biomass of game species as proposed by Linares (1976), Irvine (1987), and Greenberg (1992), this study was designed to compare relative abundance and population densities of game in three successional stages of forest. The three successional stages were categorized as 1) Combined/Early Secondary Forest (including areas categorized as Other and Plots & Gardens), 2) Late Secondary Forest with Gardens, and 3) Late Secondary Forest without Gardens. These stages represented a broad continuum of human disturbance patterns and changes in the structure and composition of forest. There were three general objectives to this study and several specific hypotheses:

First objective.--Determine the number of taxa of game or potential game species inhabiting three successional stages of forest.

Second objective.--Compare the relative abundance of wildlife in three successional stages of forest. The specific hypothesis tested was that there was no difference in the relative abundance of birds and mammals between successional stages.

Third objective.--Compare the population densities of wildlife in three successional stages of forest. The specific hypothesis tested was that there was no difference in the population densities of birds and mammals between successional stages.

Methods

Study Area

The study took place at Ejido X-Hazil y Anexos, Quintana Roo, Mexico, during 1989-1990 (total area = 552.95 km^2; Figure 2-1). Animal censuses were conducted specifically during March-November 1990 and centered around the village of X-Hazil Sur (19°23'30"N, 88°05'00"W; population = 1,040), the largest of three villages on the *ejido* (total population = 1,680; see Chapter 2 for additional information about *ejidos*). The mean annual temperature is about 26°C and the area typically has one dry season (December-May) and one wet season (June-November). Rainfall during 1 January-12 December 1990 was 1,277.3 mm (Figure 2-4). About 88.52% of the *ejido* was categorized as Late Secondary Forest, 6.07% as Plots & Gardens, 5.18% as Early Secondary Forest, and 0.23% as Other (Combined/Early Secondary Forest = 11.5%; Table 2-3). Since about 1915 the area has been occupied by Maya Indians, whose main subsistence activity has been shifting cultivation, primarily corn. Prior to 1915, Maya Indians did not occur in the area.

Ejido X-Hazil y Anexos was selected as the study area for several reasons: One, *ejido* residents practiced garden hunting and were amenable to participating in a study of the game they killed. Two, *ejido* residents practiced shifting cultivation in an area that had Late Secondary, intermediate, and Combined/Early Secondary Forests. This facilitated comparisons where differences due to actors such as soils, weather, and patterns of anthropogenic activities would be minimal.

Line Transects

Wildlife densities were determined by censuses along 12 line transects (cf., Eisenberg et al., 1979; Emmons, 1984, 1987; Glanz, 1982) during March-November 1990. Transects were thoroughly cleared of brush during September 1989-February 1990 to facilitate sightings. Nine transects had the planned length of 2 km each (Figure 4-1; Appendix H). Two transects were shorter (at 1600 m and 1960 m) due to unexpected changes in the vegetation before reaching a length of 2 km. One transect was longer (at 2130 m) to compensate for the two shorter transects. Each transect was 1 m wide;

marked at 20-m intervals with nylon flagging tape; and, except for a single transect (# 9; due to unexpected changes in the vegetation), all were oriented at a bearing of 124° (parallel to the Pemex oil exploration roads) with only minor deviations (e.g., around a fallen tree trunk). Eight of the transects extended from gardens, while four transects did not. Transects were recleared as necessary during the study. *Ejido* residents were requested not to use the transects as trails or hunting areas, but such use was noted.

Transects were categorized according to the successional stage of the forest. This designation was based on the presence ("with") or absence of gardens ("without") and vegetation type (Late Secondary Forest or Combined/Early Secondary Forest; see Chapter 6 for additional information about gardens and Chapters 2 and 3 for additional information about vegetation types). There were three categories:

One, "Late Secondary Forest without Gardens" (Transects # 2, 3, 4, and 12). These transects were located in Late Secondary Forest, an area characterized by relatively large trees and not subject to shifting cultivation for at least 75 y. Transects were located in the forest and did not extend from gardens. Wildlife population estimates based on these transects were assumed to be least affected by human disturbances or habitat alteration.

Two, "Late Secondary Forest with Gardens" (Transects # 1, 6, 7, and 8). These transects were located in Late Secondary Forest, as above, and extended from isolated, small (e.g., 1-2 ha) gardens. Transects were contiguous with gardens with the starting point of each transect located at about the midpoint of either the west or the east side of the garden. Wildlife population estimates based on these transects were assumed to be moderately affected by human disturbances or habitat alteration.

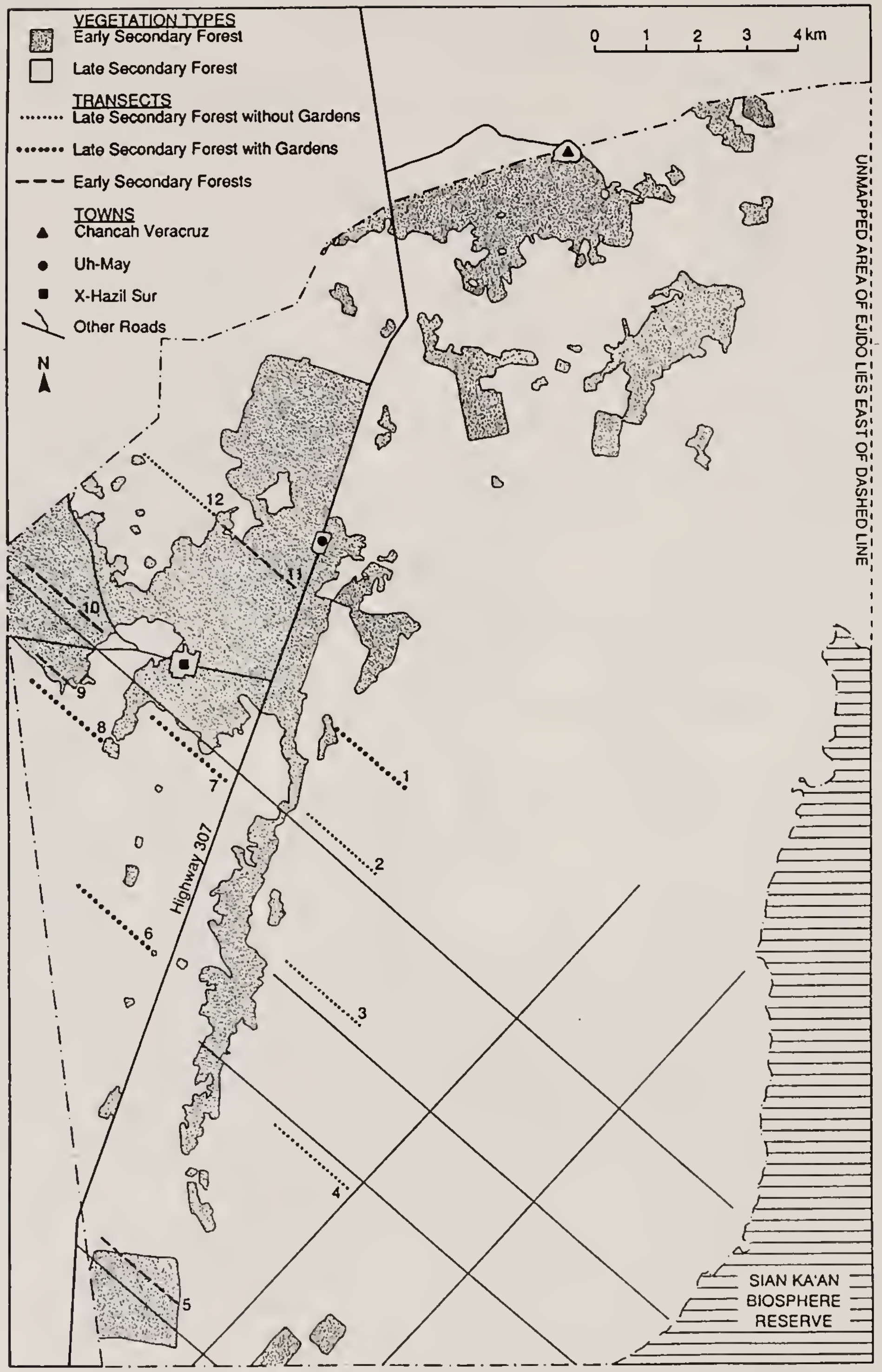

Figure 4-1. Distribution of 12 transects (ca. 2 km long each) used to census wildlife populations at Ejido X-Hazil y Anexos, Quintana Roo, Mexico, during 1990.

Three, "Combined/Early Secondary Forest" (Transects # 5, 9, 10, and 11). These transects were located in Early Secondary Forest, created as a result of shifting cultivation, and were contiguous with gardens, as above. The density of gardens in this category was relatively high. Wildlife population estimates based on these transects were assumed to be most affected by human disturbances or habitat alteration. (Note: Since Combined/Early Secondary Forest was defined by the presence of gardens, there was no transect category called "Combined/Early Secondary Forest without Gardens.")

It was not possible to construct transects in randomly chosen sites. Instead, transects were located in technically suitable sites without prior knowledge of the game populations. For transects located in Late Secondary Forest, it was especially important to select sites with reasonable access while maintaining a minimum distance of at least 300 m from the nearest garden or road. Areas slated for logging during the study were avoided. For transects located in Combined/Early Secondary Forest, it was necessary to avoid roads, gardens, cattle pastures, and the *ejido* boundaries. It also was necessary to select areas sufficiently extensive to accommodate the transect without it extending into another forest successional stage. Local residents and aerial photographs (see Chapter 3 for additional information about aerial photographs of the area) were consulted in evaluating potential sites.

<u>Wildlife Censuses</u>

Censuses were conducted by walking slowly (ca. 1 km/h; cf., Emmons [1984]) and stopping briefly every 20-40 m during two time periods, sunrise and sunset, but the results were combined for these analyses. These time periods were selected in order to include diurnal, nocturnal, and crepuscular species. Hunters also recommended these times as being propitious for observing wildlife. The starting time and walking rate of each outing were adjusted so that each census lasted about 2 h and had about 1 h of natural light and about 1 h of artificial light from battery-powered headlamps. The order of natural and artificial light necessarily was reversed for sunrise and sunset censuses, but the direction of censuses was fairly consistent for each transect.

The census team had one recorder/biololgist and one spotter (an experienced local hunter). Each team member carried a headlamp. The spotter led the team and usually made the sighting. Frequently the spotter also sighted the animal. Team members remained on the transect except to measure or confirm a sighting. All game animals sighted by team members were counted, as were some nongame animals (see Chapter 3 for additional information about game and nongame species).

For each sighting, the critical variables were based on the locations of the spotter and the animal when first noted. The following information was recorded for each sighting; species, transect number, bearing (measured with a compass and usually rounded-off to $\pm$ 2°), distance from spotter (measured to within 0.1 m with a tape measure), and forest successional stage (see Appendix I for data form). Sightings were conservative in that either the animal was directly observed or the animal's presence was confirmed by locating a fresh track, feeding sign, hair or feather, or hearing a characteristic alarm call as it fled the area. Only the first observation of an animal during a census was counted as a sighting. This problem was avoided by noting the direction and distance an animal fled and ignoring potential repeated sightings.

Outings were undertaken at a frequency of one or two times per transect per month and were conditional upon good weather, the phase of the moon, the availability of spotters, and the recent occurrence of logging activities in the vicinity of the transect. This was done to maximize the probability of seeing wildlife. Censuses were not conducted during periods of bright moonlight, heavy rains, strong winds, or if loggers had been in the vicinity of the transect within a few days of the planned census. The order in which transects were walked was random within each series of sunrise or sunset censuses.

Number of Sightings, Relative Abundance, and Population Density Estimates

Wildlife populations were compared using three measures: number of sightings, relative abundances, and population density estimates. Except for the collared peccary, the number of sightings by taxa was determined for each forest successional stage by calculating the number of individual sightings per 100 km of census transects. For the collared peccary, although 10 animals were observed (one sighting of a single individual and one sighting of at least nine individuals in a single group), these observations were combined and treated as two sightings. The number of sightings per taxa were not compared statistically between forest successional stages due to small sample sizes.

Relative abundance values were used to compare abundance differences statistically between forest successional stages. These values were determined by calculating, for each taxon, the mean number of sightings per transect per kilometer censused. A grand mean and standard error measure for each of the three forest successional stages were calculated using the four transect replicates. For convenience, these means were multiplied by the constant 10,000. These values were analyzed statistically using the nonparametric Kruskal-Wallis test.

Population density estimates (number of individuals/km^2) were determined using King's method, based on the distance between the animal and the spotter (cf., Burnham et al., 1980; Schemnitz, 1980). These estimates were summarized by forest successional stage, but not compared statistically due to small sample sizes.

Since the number of individuals sighted per taxon during the censuses was relatively low, only four taxa could be analyzed quantitatively: squirrels, coatis, kinkajous, and plain chachalacas. In order to increase the sample size for comparisons of relative abundance and population density estimates between forest successional stages, I summarize the data by taxonomic groups, as follows: marsupials and edentates, rodents, carnivores, artiodactyls, and birds. In addition, the data were summarized by game versus nongame status, as follows: game mammals, nongame mammals, game birds, and nongame birds. Thus, three types of comparisons were made.

Statistical Methods

Nonparametric tests were used to analyze census data due to small sample sizes and the high likelihood that the data were not normally distributed. A potential bias due to animal observability differences between forest successional stages was tested by comparing the mean sighting distances between the spotter and the animal when first noted. No differences were noted (Appendix J) so it was considered appropriate to compare relative abundances and population density estimates between forest successional stages. The Kruskal-Wallis test (χ^2 approximation) was used for the analyses. The following statistical terms were used; $\bar{x}$ = mean, SE = standard error, n = sample size, d.f. = degrees of freedom, χ^2 approximation = chi-square approximation, and P = probability value. All statistical analyses were conducted using SAS (SAS Institute Inc., 1988).

Limitations of the Data Sets

There were at least five main factors that must be considered when reviewing these results. One, these results were based on a small number of sightings over a short period of time at a single site. As a consequence, a small number of sightings could have a substantial impact on the relative abundance values and population density estimates for the wildlife taxa. Two, there were differences in the composition and structure of the three forest successional stages. These differences likely made it easier to observe animals in Late Secondary Forests than in Combined/Early Secondary Forests because Late Secondary Forests were more open at ground level (but see the section on mean sighting distances, below; also see Chapter 2 for additional information about the structure and composition of the forest). Three, there were differences in the nature and extent of human activity in the three forest successional stages. One would expect that game species intolerant of disturbances associated with human activity would be less abundant in areas with extensive human activities than in areas with limited activities, but this may be offset--in part--by wildlife habituation to humans. The degree of habituation by wildlife species on the study area is unknown. Four, differences in animal size, behavior, and ecology may have resulted in the populations of some species being overestimated, while others may have been underestimated. For example, the coati population may have been overestimated as this species was observed to move extensively between gardens and make a great deal of noise while feeding (B. Can Chi and M. Aban Noh, pers. comm.). Populations of ocellated turkeys and great curassows may have been underestimated as these species were observed to be highly secretive and occupy only specific areas of forest (G. Yeh Poot and A. Poot Ake, pers. comm.). Five, human hunting may have affected the behavior of some game species and made them less easy to sight than other nongame species. In summary, these factors may have affected the results, but their individual and cumulative impacts are unknown at this time.

Results

Mean Sighting Distances and Forest Successional Stages

Mean sighting distances were tested in order to determine if there might be any observability biases between forest successional stages. No significant differences ($P > 0.05$) were detected for sighting distances between forest successional stages by species (four species tested), taxonomic group (five groups tested), or game versus nongame status (four game status combinations tested; Appendix J).

Number of Taxa and Sightings

Sightings. A total of 23 taxa were sighted (16 mammals and 7 birds; Appendix J; Figure 4-2) during the 121 censuses (total distance censused = 240.460 km; total time censused = 244.27 h; Appendix H). Transects were censused five times each during the sunrise period and five or six times each during the sunset period. Censuses on Transect # 1 were discontinued after six censuses due to problems with a local resident. More than 50% of the taxa had been sighted by census number 22, while no new taxa were sighted after census number 75.

A total of 240 sightings were recorded (150 mammals and 90 birds; Appendix J). Among the mammals, the most frequently sighted taxa were squirrels (47 sightings; *Sciurus deppei* and *S.*

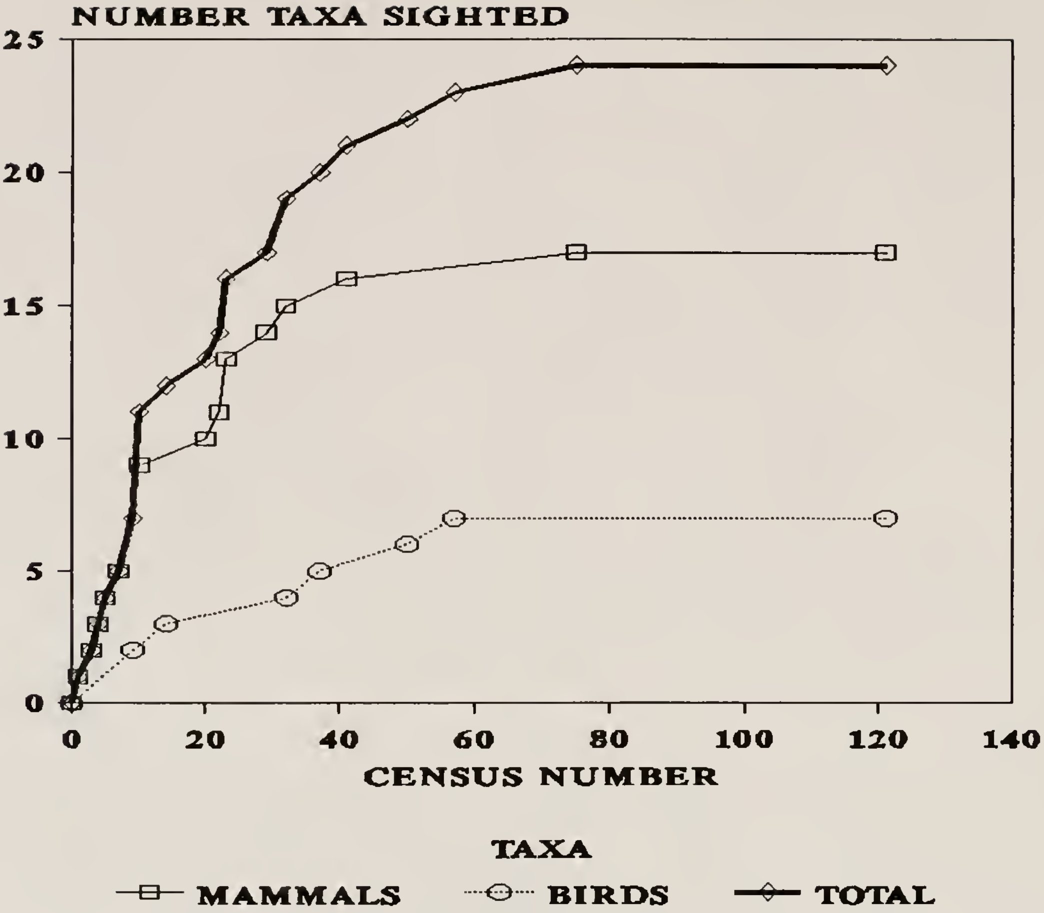

Figure 4-2. Cumulative number of avian (7) and mammalian (16) taxa sighted during 121 censuses in 1990.

yucatanensis, combined; see Appendix L for scientific and common names), kinkajous (31 sightings), and coatis (17 sightings). The plain chachalaca was the most frequently sighted bird (64 sightings). Other birds rarely were sighted.

Animals not sighted or not present. Several taxa of mammals and birds, that potentially could have been taken for subsistence purposes, were not observed during the censuses. Some of these taxa were observed at other times during the study (see Chapter 3 for an inventory of game species) or their presence was reported by local residents, while other taxa were expected to occur in the area, based on published range maps (e.g., Leopold [1977] and Peterson and Chalif [1973]), but were not observed or reported.

Among mammals, several taxa were not observed during censuses. Two primates were reported by hunters, but not observed during censuses: howler monkey (*Alouatta pigra*) and spider monkey (*Ateles geoffroyi*). The rabbit (*Sylvilagus floridanus*) and the ring-tailed cat (*Bassariscus sumichrasti*) were not reported. The porcupine (*Coendu mexicanus*), short-tailed weasel (*Mustela frenata*) and Baird's tapir (*Tapirus bairdii*) were reported (pers. obs.). Among birds, three taxa were expected, but not observed during censuses; the great tinamou (*Tinamus major*) was not reported by local residents, while the crested guan (*Penelope purpurascens*) and the black-throated (Yucatán) bobwhite (*Colinus nigrogularis*) were reported, but not observed.

Relative Abundance

Since the number of individuals sighted during the censuses was relatively low, three levels of analyses were conducted: species (four species compared), taxonomic group (five groups compared), and game versus nongame birds and mammals (four categories compared). These comparisons allowed conclusions based on the available data.

Species. Significant differences were detected for plain chachalaca sighting frequencies between Late Secondary Forest without Gardens, Late Secondary Forest with Gardens, and Combined/Early Secondary Forest (mean sighting frequencies were 1.9 individuals/10,000 km, 0.6/10,000 km, and 5.2/10,000 km, respectively; χ^2 approximation = 8.4900, d.f. = 2, P = 0.0143; Table 4-1). No significant differences in sighting frequencies were detected between forest successional stages for squirrels (P = 0.1596), coatis (P = 0.0877), or kinkajous (P = 0.0665).

Groups. Significant differences were detected for bird sighting frequencies between Late Secondary Forest without Gardens, Late Secondary Forest with Gardens, and Combined/Early Secondary Forest (mean sighting frequencies were 5.2 individuals/10,000 km, 1.3/10,000 km, and 6.8/10,000 km, respectively; χ^2 approximation = 7.2692, d.f. = 2, P = 0.0264; Table 4-1).

Significant differences also were detected for carnivore sighting frequencies between Late Secondary Forest without Gardens, Late Secondary Forest with Gardens, and Combined/Early Secondary Forest (mean sighting frequencies were 10.2 individuals/10,000 km, 3.4/10,000 km, and 0.9/10,000 km, respectively; χ^2 approximation = 6.2482, d.f. = 2, P = 0.0440; Table 4-1). No significant differences in sighting frequencies were detected between forest successional stages for marsupials and edentates (P = 0.9100), rodents (P = 0.0954), or artiodactyls (P = 0.4337).

Game versus nongame taxa. Significant differences were detected for game bird sighting frequencies between Late Secondary Forest without Gardens, Late Secondary Forest with Gardens, and Combined/Early Secondary Forest (mean sighting frequencies were 4.8 individuals/10,000 km, 1.2/10,000 km, and 5.8/10,000 km, respectively; χ^2 approximation = 7.2947, d.f. = 2, P = 0.0261; Table 4-1). No significant differences in sighting frequencies were detected between forest successional stages for game mammals (P = 0.1972), nongame mammals (P = 0.1752), or nongame birds (P = 0.1994).

Population Density Estimates

The number of wildlife sightings were sufficient to calculate several population density estimates, but not sufficient to justify a statistical analysis of population density estimates among the three successional stages of forest. In the following section, as in the previous section, the data for population density estimates were summarized by species, taxonomic group, and game and nongame birds and mammals.

Species. Among mammals, the squirrel was the most abundant species and had a higher population density in Late Secondary Forest without Gardens (10.3 individuals/km^2) than in Late Secondary Forest with Gardens (7.2 individuals/km^2) or Combined/Early Secondary Forest (4.5 individuals/km^2; Table 4-2). The plain chachalaca was the most abundant bird and had a higher population density in Combined/Early Secondary Forest (20.3 individuals/km^2) than in the other successional stages.

Table 4-1. Average sighting frequency (mean number of sightings per 10,000 km) of wildlife, summarized by species, groups, and game and nongame birds and mammals censused along 12 transects in three successional stages of forest at Ejido X-Hazil y Anexos, Quintana Roo, Mexico, during 1990 (d.f. = 2 throughout).

	Successional stages							
	Late Secondary Forest without Gardens		Late Secondary Forest with Gardens		Combined/ Early Secondary Forest			
Taxa[a]	$\bar{x}$[b]	SE	$\bar{x}$	SE	$\bar{x}$	SE	χ^2 approx.	P
a) Species								
Squirrels (47)	2.7	(0.4)	1.8	(0.3)	1.4	(0.4)	3.6699	0.1596
Coati (17)*[c]	0.3	(0.1)	1.9	(1.4)	0.0	(0.0)	4.8673	0.0877
Kinkajou (31)	2.0	(0.5)	1.4	(0.5)	0.4	(0.2)	5.4220	0.0665
Plain chachalaca (64)*	1.9	(0.7)	0.6	(0.6)	5.2	(0.2)	8.4900	0.0143
b) Groups								
Marsupials & Edentates (18)	1.6	(1.1)	0.9	(0.4)	0.7	(0.3)	0.1886	0.9100
Rodents (68)	10.3	(6.6)	3.0	(0.6)	1.8	(0.5)	4.6991	0.0954
Carnivores (55)	10.2	(8.3)	3.4	(1.7)	0.9	(0.2)	6.2482	0.0440
Artiodactyls (9)	0.3	(0.3)	0.3	(0.1)	0.6	(0.2)	1.6545	0.4337
Birds (90)	5.2	(1.7)	1.3	(0.8)	6.8	(0.5)	7.2692	0.0264
c) Game versus nongame species[c]								
Game mammals (47)*	1.4	(0.8)	3.3	(1.8)	1.0	(0.3)	3.2473	0.1972
Nongame mammals (103)	21.0	(16.3)	4.3	(0.9)	3.0	(0.4)	3.4833	0.1752
Game birds (78)*	4.8	(1.8)	1.2	(0.7)	5.8	(0.2)	7.2947	0.0261
Nongame birds (12)	0.4	(0.2)	0.1	(0.1)	1.0	(0.4)	3.2249	0.1994

[a] See Appendix L for common and scientific names. (n) = number of sightings.
[b] $\bar{x}$ = (10,000) * (average of four replicates of sightings/km).
[c] * = Game species. See Chapter 3 for additional information about game species.

Groups. Birds were more abundant in Combined/Early Secondary Forest than in Late Secondary Forest without Gardens or Late Secondary Forest with Gardens. Among the mammalian groups, rodents were most abundant and had a higher density in Late Secondary Forest without Gardens (13.5 individuals/km^2) than in Late Secondary Forest with Gardens or Combined/Early Secondary Forest. Birds had a higher population density in Combined/Early Secondary Forest (26.3 individuals/km^2) than in Late Secondary Forest without Gardens or Late Secondary Forest with Gardens.

Game versus nongame taxa. Game mammals and birds were different from each other in that game mammals were most abundant in Late Secondary Forest with Gardens (8.4 individuals/km^2), while game birds were most abundant in Combined/Early Secondary Forest (21.8 individuals/km^2; Table 4-2). Nongame birds and mammals were similar in that their respective population densities were comparable in Late Secondary Forest without Gardens and Late Secondary Forest with Gardens.

Discussion

Number of Taxa and Sightings

A total of 16 taxa and 150 individuals of mammals and 7 taxa and 90 individuals of birds were sighted during 121 censuses at Ejido X-Hazil y Anexos (total distance censuses = 240.460 km; total time censused = 244.27 h; Appendices H and J). These sightings did not include all of the taxa in the study area, however. About 25 taxa of nonvolant mammals, including game and nongame species, were killed by hunters (see Appendix F) or sighted during censuses, while another 4 taxa were sighted incidental to other activities during the study. Thus, excluding small rodents, there were about 29 taxa of nonvolant mammals at the study area.

Compared with the number of nonvolant mammals sighted at other Neotropical sites, the number of taxa sighted at Ejido X-Hazil y Anexos was low. For example, Glanz (1990) reported 39 species for Barro Colorado Island, Panama. In Costa Rica, Wilson (1983) reported 43 species for La

Selva and 59 species for Osa Peninsula. In Peru, Patton et al. (1982) and Terborgh et al. (1984) reported 59 species for Rio Cenepa and 68 species for Cocha Cashu. While these sites differ in many

Table 4-2. Population density estimates (individuals/km^2; total number of sightings [n]) determined by King's Method and summarized by species, taxonomic groups, and game and nongame birds and mammals.

	Successional Stages		
Taxa[a]	Late Secondary Forest without Gardens	Late Secondary Forest with Gardens	Combined/Early Secondary Forest
a) Species			
Squirrels[b]	10.3 (22)[c]	7.2 (13)	4.5 (12)
Coati*[d]	1.0 (2)	3.9 (15)	--- (0)
Kinkajou	5.6 (16)	5.5 (12)	1.6 (3)
Plain chachalaca*	8.7 (16)	2.4 (5)	20.3 (43)
b) Groups			
Marsupials & Edentates	2.8 (4)	4.9 (8)	3.4 (6)
Rodents	13.5 (29)	10.8 (24)	5.7 (15)
Carnivores	6.8 (19)	9.5 (29)	2.6 (7)
Artiodactyls	0.4 (2)	0.8 (2)	1.7 (5)
Birds	10.4 (24)	5.0 (10)	26.3 (56)
c) Game versus nongame species[d]			
Game mammals*	4.2 (11)	8.4 (28)	3.0 (8)
Nongame mammals	18.2 (43)	18.4 (35)	10.1 (25)
Game birds*	11.7 (21)	4.7 (9)	21.8 (48)
Nongame birds	0.5 (3)	0.4 (1)	4.6 (8)

[a] See Appendix L for common and scientific names.
[b] Composed of *Sciurus deppei*, *S. yucatanensis*, and an unidentified squirrel (not a new taxon).
[c] (n) = Number of sightings.
[d] * = Game species. See Chapter 3 for additional information about game species.

aspects, they are similar in being forested Neotropical areas that share comparable faunas.

The most frequently sighted taxa at Ejido X-Hazil y Anexos were the plain chachalaca (n = 64 sightings), squirrels (n = 47), kinkajou (n = 31), and coati (n = 17). Of these three, however, only the coati and plain chachalaca were considered as game species by Maya hunters (see Chapter 3 for a description of game species).

At least three environmental variables may be responsible for the abundance of wildlife at Neotropical forest sites (Emmons, 1984): soil type, undergrowth density, and rainfall and seasonality. Neither undergrowth density nor rainfall and seasonality were analyzed with respect to wildlife densities at Ejido X-Hazil y Anexos. Soil properties, however, were studied by Noguez-Galvez (1991) and can help explain the low number of wildlife taxa in the study area as soils help determine the type of vegetation that an area potentially can support.

The soils at Ejido X-Hazil y Anexos, according to the FAO classification system, correspond to the Order Rendzinas, Suborder Calcomorphics, while according to the USDA classification system, these soils correspond to the Order Mollisols, Suborder Rendolls (United States Department of Agriculture, 1960). At Ejido X-Hazil y Anexos, these soils have good structure; drainage; and a high content of organic matter, calcium, carbonates, and bicarbonates (Noguez-Galvez, 1991). As a result of a shortened fallow period, from 20 y previously to 10 y at present, however, soils at X-Hazil now are nutrient-poor. Noguez-Galvez (1991) predicted that serious degradation of the soils and cover vegetation will occur within a short period of time if this frequency of forest clearing continues. While the length and severity of this nutrient deficiency problem are unknown, it is quite possible that the soils and cover vegetation at the study area consequently are unable to support wildlife population densities found elsewhere in the Neotropics.

Soil fertility has been used to explain differences in animal biomass levels in Neotropical forests in South America. Janzen (1974) proposed that animal biomass should be less on nutrient-poor soils that produce black-water rivers in tropical forests than on soils that produce white-water rivers. The mechanism predicted for this difference was the high level of toxic secondary chemicals in plant tissues. Eisenberg (1979) and Emmons (1984), based on an analysis of variations in mammal densities among various Neotropical sites, supported this hypothesis that areas with poor soils have fewer individuals than areas with rich soils, but did not necessarily agree with the mechanism proposed by Janzen (1974).

Historical factors can also affect animal species abundance and diversity. Due to its location on the land corridor that joins North and South America, the flora and fauna of the Yucatán Peninsula strongly reflect the mingling of species that resulted after the closing of the Panamanian land bridge about three million years ago (Graham, 1993; Haffer, 1974; Stelhi and Webb, 1985). The impact of the land bridge was especially notable on terrestrial mammals as nearly half of the families and genera that now occur in South America belong to groups that emigrated from North America during the last three million years (Marshall, 1988). A substantial number of South American mammalian taxa likewise migrated to North America, but were less successful in establishing themselves than their North American counterparts (Webb and Marshall, 1982). These movements continue today as the distribution of the North American coyote (*Canis latrans*) approaches Colombia and the distribution of the South American armadillo (*Dasypus novemcinctus*) moves northward into southern portions of the United States (Hall, 1981).

A second historical factor affecting the distribution and abundance of plants and animals is the arrival of people to the New World. Crossing the Bering land bridge from Asia to North America about 11,000-12,000 y ago, humans occupied most or all of the New World within possibly 1,000 y (Martin, 1973). The human impact on the fauna was immediate and widespread as most of the large-bodied mammals in North and South America went extinct (Marshall et al., 1984). Although Markgraf (1985) proposed that climate change was responsible for these extinctions, Marshall (1988) attributes the loss of these species to human hunters.

The third historical factor important here is the development of the Maya civilization. While there is some debate about when people first arrived in Mesoamerica (cf., Adams, 1991; Martin, 1973; Nesbitt, 1980; Piperno et al., 1990), a tangible Maya civilization dates from about 1,500 B.C.

(Andrews, 1960, 1965; Deevey et al., 1979). At the height of the Maya civilization, roads, villages, large ceremonial centers, and extensive agricultural fields supplied with water by canals occurred throughout the Yucatán Peninsula to Guatemala and Honduras (Hammond, 1982a, 1982b, 1986; Turner, 1974, 1990; Turner and Harrison, 1983). The impact of these activities on plants and animals in Mesoamerica can only be surmised. Likewise, the impact of the fall of the Maya civilization about 900 A.D. on plants and animals and the resulting decrease in human activities has yet to be determined. Change persists, however, as humans now exploit lumber, *chicle*, and other nontimber forest products in Quintana Roo and the southern portion of the peninsula (Edwards, 1986; Konrad, 1988).

Two additional factors affecting animal populations in other areas may also be affecting animal populations at Ejido X-Hazil y Anexos; human hunters and large predators. In a study of tapir (*Tapirus bairdii*) abundance in Belize, Fragoso (1991, 1992) determined that among such factors as logging, disease, habitat destruction, and shifting cultivation, the most parsimonious explanation for the low number of tapirs was human hunting. Similarly, Glanz (1991) compared mammal abundances at protected and unprotected areas in central Panama and compared them with Barro Colorado Island, which is a protected area, but also lacks large predators such as jaguars (*Panthera onca*) and pumas (*Felis concolor*). Glanz (1991) noted dramatic differences in mammal densities among sites and attributed these differences to the impacts of hunting by humans rather than due to the absence of large predators, as had been noted by Emmons (1987) at other Neotropical forested sites.

Forest Successional Stages and Relative Abundance of Birds and Mammals

The study area had three forest successional stages that differed with respect to degree of human disturbance, the abundance of gardens, and the number and kinds of crops planted in the gardens. Birds and mammals were expected to select for or against the different stages according to their individual requirements. Few clear patterns, however, were noted.

At the species level, a significant difference in sighting frequency between forest successional stages was observed only for the plain chachalaca ($\underline{P}$ = 0.0143; Table 4-1). No significant differences were observed for the other three species that were compared. The plain chachalaca, a game species, was most frequently sighted in Combined/Early Secondary Forest ($\bar{x}$ = 5.2 sightings/10,000 km) and least frequently sighted in Late Secondary Forest with Gardens ($\bar{x}$ = 0.6 sightings/10,000 km; Table 4-1). This agreed with hunter reports that the plain chachalaca foraged, displayed, and nested in the vicinity of gardens and roads, but rarely ventured into Late Secondary Forest.

When game and nongame birds and mammals were compared, few clear patterns likewise were noted. Among the four animal categories, significant differences in sighting frequencies between successional stages were observed only for game birds ($\underline{P}$ = 0.0261; Table 4-1). The category game birds, however, was composed primarily of plain chachalaca sightings (64 of 78 sightings).

These findings suggested that at Ejido X-Hazil y Anexos the frequency with which birds and mammals were sighted did not vary greatly between the three successional stages. This was unexpected given the distribution of game kill sites in the four main vegetation types (see Appendix G), especially in the vegetation type categorized as Plots & Gardens, and the comments of hunters that animals were more noticeably abundant in some areas and less abundant in others.

One possible explanation for an apparent lack of clear patterns of habitat use by wildlife of different forest successional stages was the small sample size of sightings. Only 240 animals were sighted; about 1 individual/km or 1 individual/h. A larger sample size likely would identify significant differences in use of different successional forest stages by wildlife.

Another possible explanation for an apparent lack of clear habitat use patterns by wildlife was the mobility of the animals, location of the 12 census transects (see Figure 4-1), and high degree of interspersion of the various vegetation types (see Figure 2-4). Although four transects were located in Late Secondary Forest without Gardens, they may have been located too close to other vegetation types to differentiate clearly any habitat use differences by wildlife. While it may have been desirable to have located the Late Secondary Forest without Gardens transects further to the east of Route 307, the distribution of roads and trails in the forest and the transition from medium- to low-height forest and savannah may have introduced other complications.

Rank Order of Take Versus Sighting Frequency

A comparison of game harvest at Ejido X-Hazil y Anexos with the frequency at which game animals were sighted during censuses suggests that the more-frequently-taken game animals also were the more-frequently-sighted game animals. The coati and plain chachalaca were the most frequently taken game species, at 167 kills each (Table 4-3). The plain chachalaca was the most frequently sighted game species (64 sightings), while the coati ranked second (17 sightings; Table 4-3). Conversely, the white-lipped peccary, great curassow, and ocellated turkey were rarely taken or sighted. While not analyzed statistically, these comparisons indicate that Maya hunters at Ejido X-Hazil y Anexos either concentrated their efforts more on the common game species and less on the rare species or, perhaps more simply, harvested the species that were more frequently encountered.

Comparative Population Density Estimates

Mammal population densities have been calculated for several sites in Neotropical forests and permit a comparison with some taxa that occur at Ejido X-Hazil y Anexos. At Ejido X-Hazil y Anexos, when both game and nongame mammals are considered, the squirrel (two taxa combined) was the most abundant taxon at 4.5-10.3 inds./km^2, followed by the kinkajou (1.6-5.6 inds./km^2) and the coati (1.0-3.9 inds./km^2; Table 4-4). Squirrels also had the greatest population densities at two other sites: Panama (180 inds./km^2; Glanz [1982]) and Sierra Chame, Guatemala (100 inds./km^2; Hendrichs [1977]), while they were relatively uncommon at Guatopo, Venezuela (Eisenberg et al., 1979), Cocha Cashu, Peru (Emmons, 1987; Terborgh, 1983), Cabassou, French Guiana (Charles-Dominique et al., 1981), and Tikal, Guatemala (Cant, 1977). On the other hand, excluding bats and small rodents, opossums were among the most abundant mammals at three of the six Neotropical sites (25-65 inds./km^2; Venezuela, Peru, and French Guiana), while they were relatively uncommon at Ejido X-Hazil y Anexos.

When the population density estimates are compared, it is clear that mammal populations at Ejido X-Hazil y Anexos were much less dense than those at the other Neotropical sites mentioned above. For example, squirrel densities at Panama (Glanz, 1982) were about 17 times greater than

Table 4-3. Reported number of individuals taken by Maya hunters at X-Hazil Sur versus number of sightings during animal censuses (game species only).

Taxa	Total number of individuals taken	Rank order (take)	Total number of sightings	Rank order (sightings)
a) Mammals				
Pocket gopher	53	3	1	10
Paca	47	4	8	5
Agouti	35	6	12	3
Coati	167	1	17	2
White-lipped peccary	3	12	0	11
Collared peccary	40	5	2	8
Brocket deer	16	8	4	6
White-tailed deer	24	7	3	7
Game mammals	385		47	
b) Birds				
Thicket tinamou	13	9	12	3
Great curassow	13	9	0	11
Plain chachalaca	167	1	64	1
Ocellated turkey	6	11	2	8
Game birds	199		78	
Total (mammals + birds)	584		125	

those at the study area (Table 4-4). For the coati and kinkajou, population densities at the other sites were about five times as great at the other sites as at Ejido X-Hazil y Anexos, while it is not possible to generalize numerically about the population densities of the remaining taxa of mammals, it is clear that the densities at Ejido X-Hazil y Anexos were much lower.

Table 4-4. Estimated population densities of mammals at Ejido X-Hazil y Anexos compared with those at six other study areas in Neotropical forests (summarized from Glanz [1990]).

	Study area (no. inds./km²)						
Taxa[a]	This study[b]	BCI, Panama[c]	Guatopo, Venezuela[d]	Cocha Cashu, Peru[e]	Cabassou, French Guiana[f]	Sierra Chame, Guatemala[g]	Tikal, Guatemala[h]
Didelphis	Present	47	65	55	25-50		
Tamandua	Present	5	6	?[i]	?		
Dasypus	Present	53	4	?	?		
Sciurus	4.5-10.3	180	25	25	Common	100	> 9
*Orthogeomys**	Present						
*Agouti**	Present	40	18	3.5	Common	30	8
*Dasyprocta**	Present	100	63	5.2	Common	30	8
Urocyon	Present						
*Nasua**	1.0-3.9	24	---[j]	< 1	Present	15	20
Potos	1.6-5.6	20	---	20	20-30	20	74
Eira	Present	1.6	2	?	Present	1	2
Conepatus	Present						
*Tayassu**	Present	9.3	0.19	5.6		10	
*Mazama**	Present	2	5.3	2.6		20[k]	
*Odocoileus**	Present	0.7	---	---		20[k]	

[a] Includes only those mammals observed at Ejido X-Hazil y Anexos. * = game species at Ejido X-Hazil y Anexos.
[b] Range of values presented for three vegetation types.
[c] Barro Colorado Island; Glanz (1982).
[d] Eisenberg et al. (1979).
[e] Emmons (1987) and Terborgh (1983).
[f] Charles-Dominique et al. (1981).
[g] Hendrichs (1977).
[h] Cant (1977).
[i] ? = Unknown.
[j] --- = Does not occur.
[k] *Mazama* and *Odocoileus* combined.

A final consideration involves the practice of keeping domestic animals. Maya Indians in the Yucatán Peninsula have had access to pigs, chickens, horses, cattle, and other kinds of livestock since the early 1500s, following the Spanish conquest (Redfield and Villa Rojas, 1962; Villa Rojas, 1987). In order to protect these animals, the Maya likely killed the large predators, venomous snakes, and other noxious animals in the vicinity of their villages. The accumulated effects of these attempts to eradicate certain kinds of dangerous wild animals in the area over 450 y are unknown, but likely have affected the population densities of many game birds and mammals.

In conclusion, in this assessment of wildlife populations at Ejido X-Hazil y Anexos, I have shown that densities are very low, compared with other Neotropical forested sites. This was true for birds as well as mammals, especially game species. While the reasons for these low densities are unknown, it is possible that low soil nutrient levels due to increasingly shorter fallow periods have negatively affected the vegetation of the area. It is also quite possible that the occurrence of jaguars and pumas in the area (Navarro L. et al., 1990) and the occurrence of Maya hunters during 2,000-3,000 y are also responsible in part for low animal abundance levels. Most likely low animal densities are a result of the combination of many of these factors.

With respect to garden hunting, the results obtained during this study generally did not detect differences in population densities of game species between areas with and without gardens. This could mean either that differences did not occur or that differences did not exist. Local hunters reported that wildlife populations were denser in areas with gardens than in areas without gardens, but could not quantify the magnitude of these differences. Density differences were indirectly confirmed by the relatively large proportion of game taken in areas categorized as Plots & Gardens (see Chapter 3). However, given the small size of the study area, close proximity of census transects, and large home ranges of many game species, it may not have been possible to detect differences in population densities of game species.

CHAPTER 5
CONSUMPTION OF GARDEN CROPS BY GAME ANIMALS IN QUINTANA ROO, MEXICO

Introduction

As a game-procurement system, garden hunting has been described as more similar to harvesting vegetable products and marine resources than to hunting in tropical forests (Linares, 1976). Basing her conclusions on an archeological study of a group of indigenous people in northwestern Panama who practiced shifting cultivation, Linares (1976) described the garden hunting system and determined that it focused on specific taxa of terrestrial mammals. One element of this system, it is hypothesized, is that many of the mammals taken are dependent upon crops found in gardens. A second element of this hunting system, it is hypothesized, is that those mammals, as a consequence of consuming crops, are found at greater population densities in forested areas with gardens than in forested areas without gardens. In response to the higher densities of these mammals around gardens, hunters have shifted their methods for pursuing wild animals from tropical forest hunting, where a wide variety of arboreal and terrestrial birds and mammals are harvested, to garden hunting, where a narrow range of terrestrial mammals are taken.

Although Linares (1976) did not present corroboration for either hypothesis, the model of garden hunting has been applied to game harvest practices by hunters in other areas. It has been suggested, for example, that Maya hunters in Mexico practice garden hunting (Greenberg, 1992; Nations and Nigh, 1980). Given that many of the species taken by the Maya also were reported for Panama (see Chapter 3), it may be possible to use the example of subsistence hunting by Maya Indians in Mexico to support the model of garden hunting.

The data about food habits of game animals must be considered within the context of the overall study. In Chapter 3, data were presented about the distribution of game kills in the various vegetation types that occur on the study area. Given that many animals were taken while they were feeding, their diet and the vegetation type of the kill site are related. In Chapter 4, data were presented about the differences in wildlife densities in three forest successional stages: Late Secondary Forest without Gardens (areas with little habitat or human disturbance), Late Secondary Forest with Gardens (moderately disturbed areas), and Combined/Early Secondary Forest (highly disturbed areas). In Chapter 6, data will be presented about the characteristics of Maya gardens and their use by game. In this chapter, data about the nature, extent, and seasonality of consumption of garden crops by wild animals at Ejido X-Hazil y Anexos will be presented.

There were four general objectives for this study and several hypotheses:

First objective.--Quantify and characterize food items consumed by game species, identifying the most frequently taken food items, plant parts consumed, and proportion of plant and animal matter.

Second objective.--Compare the percent occurrence of major crop species in the diets of game species. The hypothesis was that there were no differences in diets, by game species, with respect to either the number of crop taxa consumed or the percent occurrence of crops in stomach samples.

Third objective.--Compare seasonal variation in consumption patterns of major crop species by selected game species. Two hypotheses were examined: One, for each major crop species, there was no difference, by garden season for all game species combined, in the percent occurrence or the percent volume by plant part of the individual major crop species in the diet. Two, for each selected game species, there was no difference, by garden season for each individual crop species, in the percent volume or percent occurrence of the individual major crop species in the diet.

Methods

Study Area

The study took place at Ejido X-Hazil y Anexos, Quintana Roo, Mexico, during 1989-1990 (total area = 552.95 km^2; Figure 2-1). Crop consumption data were obtained from game taken by residents at the village of X-Hazil Sur (19°23′30″N, 88°05′00″W; population = 1,040), the largest of three villages on the *ejido* (total population = 1,680). The mean annual temperature is about 26°C and the area typically has one dry season (December-May) and one wet season (June-November). Rainfall during 1 January-12 December 1990 was 1,277.3 mm (Figure 2-4). About 88.52% of the *ejido* was categorized as Late Secondary Forest, 6.07% as Plots & Gardens, 5.18% as Early Secondary Forest, and 0.23% as Other (Table 2-3). Since about 1915 the area has been occupied by Maya Indians, whose main subsistence activity has been shifting cultivation, primarily corn. Prior to 1915, Maya Indians did not occur in the area.

Collection and Measurement of Stomach Contents

The results of this chapter were based on stomach contents obtained from freshly killed game taken by hunters for subsistence purposes at X-Hazil Sur during June 1989-October 1990. Each reported game kill was measured and weighed, stomach contents were collected, and the hunter was interviewed regarding the particulars of the hunt (see Chapter 3). For mammals, the term stomach contents is taken to mean the contents of the stomach proper, while for birds this term includes the contents of the esophagus, crop, proventriculus, and gizzard.

For each stomach sample, including parasites and digestive juices, the total wet volume of the material was measured using a beaker, small syringe, graduated cylinder, or calibrated plastic bucket. For small quantities, ≤ about 100 ml, the volume was measured to within 1 ml. For large quantities, ≥ about 500 ml, the volume was measured to within 50-100 ml, depending upon the total volume of the specimen. After the total volume of the stomach sample was determined, the contents were washed with water in a food strainer (mesh size about 1 mm) to remove the digestive juices and fine food particles. For small volumes, the entire contents (minus juices and fine particles) were preserved, while for large volumes, about 25-50% of the contents (up to about 500 ml, minus juices and fine particles) was preserved. Stomach contents were preserved in 15% formalin solution.

Identification of Stomach Contents

Stomach contents were identified on-site at X-Hazil Sur. These identifications were based on a visual examination of the washed stomach contents in which the food items were separated by size, shape, color, and plant or animal part. Food items were categorized as fruits or seeds (abbreviated as FS in tables and figures), leaves (L), animal material (AM; e.g., hair, snail shells, or insect antennae), and other (O; e.g., tubers, roots, stems, plastic, rocks, or soil; Appendix M). Two local Maya hunters, each about 45 y old and with extensive hunting, logging, and gardening experience in the area, identified the stomach contents. These men were provided with the local common name of the game animal, the vegetation type of the kill site, and the time of year when the animal was killed. Supported by this information, these individuals studied the sample, identified the food items, and indicated the local common name in Maya for the material. The men were not pressured to make determinations when they were not sure of the identity of the food item. In some cases, the men consulted with other village residents to identify an unknown food item. By using the same two individuals to identify all of the stomach content samples and by allowing these men to consult with others, the consistency of the identifications was enhanced.

The identification of stomach contents and subsequent measurement by species and food part were based on a complete examination of some specimens and on a partial examination of other specimens. For stomach contents of relatively small volume, the entire contents were examined, while for large volumes, a random subsample of about 50-100 ml was examined. After each food item had been identified, its volume was measured to within 0.5 ml, and the specific plant or animal part that had been consumed was recorded. Food items that measured < 0.5 ml (e.g., body parts of insects or snails) were categorized as "trace" and considered to have a volume of 0.0001 ml for analytical purposes. Trace items were reported in the tables and appendices as "< 0.0%."

The scientific name of each food item was determined from a reference collection of local plants and animals. Most of these specimens were initially identified by hunters with the local common name in Maya. About 265 specimens of animals and plants (most with flowers or fruits) were collected and identified. Reference plant specimens were identified by J. Chavelas Polito, Director, Centro Experimental Forestal "San Felipe Bacalar," and E. Cabrera Cano, Botanist, Centro de Investigaciones de Quintana Roo (CIQRO). Reference animal specimens were identified by various specialists from CIQRO and Universidad Nacional Autónoma de México (see Acknowledgments). Plants usually were identified to the species level. Insects were identified to the level of order, while other animals usually were identified only to the level of class due to the damage they had incurred while being eaten. The reference collection and the stomach contents, including additional specimens not identified during this study due to time constraints, were deposited in the scientific collections at CIQRO, Chetumal, Quintana Roo, Mexico.

The data are presented by food item as percent occurrence and percent volume of the material that was analyzed (entire stomachs or subsamples). Empty stomachs (volume = 0.0 ml) were excluded from these analyses. Percent occurrence was defined as the number of stomachs in which that food item occurred. Percent volume was defined as the ratio between the total volume of a separate food taxon and the total volume of all food taxa combined. All of the volumes were based on preserved stomach contents.

Game and Crop Species

A total of 12 game species and 13 main crop species were considered in this study (Table 5-1). Game species were the taxa taken locally for subsistence purposes (see Chapter 3). The main crop species (11 species and 2 combined categories [i.e., Other and Fruits]) were the taxa grown locally for

Table 5-1. Game species and main crop species at Ejido X-Hazil y Anexos, Quintana Roo, Mexico, during 1989-1990.

Scientific name	Class or Order/Family[a]	Common name
a) Game species[b]		
Orthogeomys hispidus[c]	Mammalia/Geomyidae	Pocket gopher
*Agouti paca**	Mammalia/Agoutidae	Paca
*Dasyprocta punctata**	Mammalia/Dasyproctidae	Agouti
*Nasua nasua**	Mammalia/Procyonidae	Coati
Tayassu pecari	Mammalia/Tayassuidae	White-lipped peccary
*Tayassu tajacu**	Mammalia/Tayassuidae	Collared peccary
Mazama americana	Mammalia/Cervidae	Brocket deer
Odocoileus virginianus	Mammalia/Cervidae	White-tailed deer
Crypturellus cinnamomeus	Aves/Tinamidae	Thicket tinamou
Crax rubra	Aves/Cracidae	Great curassow
Ortalis vetula	Aves/Cracidae	Plain chachalaca
Agriocharis ocellata	Aves/Meleagrididae	Ocellated turkey
b) Main crop species[d]		
*Ipomoea batatas**	Tubiflorales/ Convolvulaceae	Sweet potato
*Cucurbita moschata**	Campanulales/ Cucurbitaceae	Squash
Dioscorea alata[e]	Liliales/Dioscoreaceae	Yam
Cnidoscolus chayamansa	Geraniales/ Euphorbiaceae	Chaya
*Manihot esculenta**	Geraniales/ Euphorbiaceae	Yuca
Cajanus cajan	Rosales/ Fabaceae (Leguminosae)	Lentil
*Zea mays**	Graminales/Gramineae	Corn
Pachyrrhizus erosus var. *palmatilobus*	Rosales/Leguminosae	Jícama
Phaseolus lunatus	Rosales/Leguminosae	Ib bean
*Phaseolus vulgaris**	Rosales/Leguminosae	Kidney bean

Scientific name	Class or Order/Family[a]	Common name
Capsicum annum	Tubiflorales/ Solanaceae	Chili
-----*		Other/Zacate[f]
-----		Fruits[g]

[a] Class and Family for game species (sorted taxonomically). Order and Family for main crop species (sorted alphabetically by Family).
[b] Game species based on hunter survey during 1989-1990 (see Chapter 3). * = Selected game or main crop species.
[c] Pocket gophers were excluded from food item analyses because stomach contents were not readily available or identifiable.
[d] Main crop species based on gardener survey during 1989-1990 (see Chapter 6).
[e] The term "yam" refers primarily to *Dioscorea alata*, but X-Hazil Sur residents also cultivated another *macal* that was not identified, but may be either *Colocasia esculenta* or *Xanthosoma yucatanense* (Arales/Araceae).
[f] The term "other" refers primarily to *zacate* (*Scleria lithosperma* [Graminales/Cyperaceae]), but also includes an unidentified bean (*Phaseolus* sp.), an unidentified squash (*Cucurbita* sp.), and an unidentified cucumber (*Cucumis* sp.).
[g] The term "fruits" was used by X-Hazil Sur residents to refer to several species of plants. For analytical purposes, these species were combined but included the following: Anacardiaceae, mango (*Mangifera indica*); Bromeliaceae, pineapple (*Ananas sativa*); Cariacaceae, papaya (*Carica papaya*); Cucurbitaceae, watermelon (*Citrullus vulgaris*); Gramineae, sugarcane (*Saccharum officinarum*); Lauraceae, avocado (*Persea americana*); Leguminosae, peanut (*Arachis hypodaea*); Musaceae, banana (*Musa* sp.); Rutaceae, lime (*Citrus aurantifolia*) and orange (*C. sinensis*); and Sapotaceae (*Pouteria mammosa*).

subsistence purposes (see Chapter 6). Crops grown in house gardens for subsistence purposes or commercially in the truck gardens along Mexican Route 307 (see Chapter 2) were not included.

In order to focus on the best available data during the analyses, several game species were excluded from further consideration either because they ate few, if any, crops or their consumption of crops was only for a limited period of time during the year. The following game species frequently were taken in gardens by hunters or frequently consumed crop species and were designated as selected game species: paca, agouti, coati, and collared peccary. The following crop species were consumed by game species and were designated as major crop species: sweet potato, squash, yuca, corn, kidney bean, and other/zacate.

Garden Season Categories

The consumption of major crop species by selected game species was analyzed with respect to time periods that reflected seasonal variations in weather as well as human activities. Three garden season categories were designated, based on weather, garden activities, timber harvest, and *chicle* tapping (cf., Barrera de Jorgenson, 1993; see Chapter 2 for additional information):

> One, "Clear and burn" was the period from January to April. During this period, the weather was dry and getting warmer, gardeners cleared and burned new garden sites, old gardens and any leftover crops were left unattended, timber was harvested, and by about the end of February the *chicle* tapping season was over.
>
> Two, "Plant and weed" was the period from May to August. During this period, the weather was rainy and hot, gardeners planted and weeded new gardens, little timber was harvested, and by late August the *chicle* tapping season was just beginning.
>
> Three, "Weed and harvest" was the period from September to December. During this period, the weather was rainy and getting cooler, gardeners weeded and harvested their gardens, new garden sites were selected, no timber was harvested, and the *chicle* tapping season was underway.

Statistical Analyses

The analyses in this chapter were primarily descriptive. This was due to the fact that sample sizes were too small for comparisons. The following terms were used: $\bar{x}$ = mean, SE = standard error, and n = sample size.

Limitations of the Data Sets

Several factors must be considered when reviewing these results. One, these data were based on reports provided by cooperating hunters (see Chapter 3 for additional information). Not all game kills were reported to me. Based on my calculations, conversations with hunters, and information provided by village residents, the reported number of game animals taken probably represents about two-thirds of the total game harvest at X-Hazil Sur during the course of my data collection. Two, the hunters selected when to hunt, what to shoot, and where to go. The reported kills, thus, do not represent a random sample of the game available or the foods they would consume. Three, these data were based on animals that were killed by hunters and do not reflect animals that escaped being killed. For most game species, there were seasonal differences in the age, sex, and number of individuals taken. These results, then, could be biased if individual preferences for or against certain crop species placed a wild animal at a different risk level than other individuals in the population. As a consequence, some of the results may be biased due to the actions of hunters or the behavior of individual game animals.

Another factor that must be considered while reviewing these data is that many animals, especially those taken in gardens, were killed while they had empty stomachs. Hunters reported that many of the animals taken in gardens obviously were looking for food and probably would have eaten garden crops. As a consequence, these results of crop consumption should be taken as minimum values for the importance of crops to game species. This problem will be discussed below.

Results

Food Items Consumed by Game Species

Food items were identified for 11 of the 12 game species taken by Maya hunters at X-Hazil Sur. For two reasons, food items were not identified for the pocket gopher: One, local residents always cooked and consumed the entire pocket gopher; thus, stomach contents normally were not available for collection. Two, pocket gophers normally ground up their food into extremely fine particles that could not be readily identified through visual, macroscopic examination of the material (personal observation). For each of the remaining 11 game species, the following variables were summarized: the number of stomachs analyzed, the volume of stomach contents, proportion of sample analyzed (for large samples), the most frequent food items by percent occurrence and percent volume, the percent volume of plant and animal material, and the percent volume of crop species (see Chapter 6 for a description of crop species).

Game Species Accounts

A total of 28 food items were recorded for the paca (n = 36 stomachs; total volume analyzed = 1886.5 ml; Appendix N). By percent occurrence, the most frequent food item was fruits/seeds from *Manilkara zapota* (Sapotaceae) at 47.2%. By percent volume, fruits/seeds from *Manilkara zapota* also was the most commonly taken food item at 26.6%. Plant material composed 99.8% (23 taxa), by percent volume, of paca stomach contents, while animal material composed 0.2% (five taxa). About 94%, by percent volume, of the paca diet consisted of fruits and seeds (Figure 5-1). By percent volume, crop species composed a total of 35.9% (four taxa: corn, squash, yuca, and sweet potato) of the stomach contents.

For the agouti, a total of 21 food items were recorded (n = 26 stomachs; total volume analyzed = 1167.5 ml; Appendix O). The most frequent food item was fruits/seeds from *Manilkara zapota* at 38.5%, by percent occurrence. Corn at 25.5% and sweet potato at 20.2%, both by percent volume, were the two most commonly taken food items. By percent volume, plant material composed 99.9% (19 taxa) of agouti stomach contents, while animal material composed 0.1% (two taxa). About 98%, by percent volume, of the agouti diet consisted of fruits and seeds (Figure 5-1). Crop species (four taxa: corn, sweet potato, squash, and zacate) composed a total of 59.3%, by percent volume, of the stomach contents.

A total of 49 food items were recorded for the coati (n = 129 stomachs; total volume analyzed = 4678.5 ml; Appendix P). By percent occurrence, the most frequent food items were an unidentified

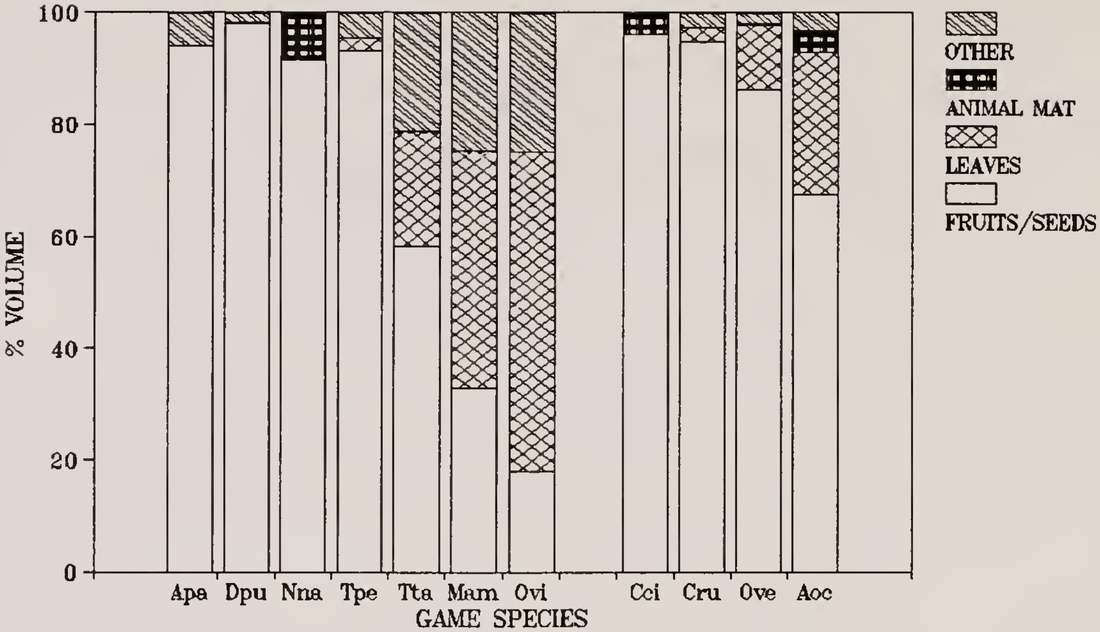

Figure 5-1. Proportion (percent volume) of food items identified from stomach contents of game species taken by Maya hunters at X-Hazil Sur, Quintana Roo, Mexico, during June 1989-October 1990. (Food items: FRUITS/SEEDS = fruits or seeds, LEAVES = leaves, ANIMAL MAT = animal material, and OTHER = other [see Methods for further information]. See Table 5-2 for key to species abbreviations.)

slug (Class Gastropoda) at 50.4%, an unidentified insect (Order Orthoptera) at 44.2%, and corn at 40.3%. By percent volume, corn at 53.5% and fruits/seeds from *Manilkara zapota* at 19.0% were the two most commonly taken food items. Plant material composed 91.6% (29 taxa), by percent volume, of the stomach contents, while animal material composed 8.4% (19 taxa). About 92%, by percent volume, of the coati diet consisted of fruits and seeds, while 8% consisted of animal matter (Figure 5-1). By percent volume, the single crop species corn composed 53.5% of the stomach contents.

For the white-lipped peccary, a total of 17 food items were recorded (n = 3 stomachs; total volume analyzed = 208.0 ml; Appendix Q). The most frequent food items were fruits/seeds from *Brosimum alicastrum* (Moraceae) at 100.0%, stems/roots from an unidentified plant called *Can pe tzu* at 100.0%, and leaves from *Psychotria* sp. (Rubiaceae) at 100.0%, by percent occurrence. *Brosimum* *alicastrum* at 87.7%, by percent volume, was the most common taken food item. By percent volume, plant material composed 100.0% (14 taxa) of white-lipped peccary stomach contents, while animal material composed < 0.0% (trace amounts of three taxa). About 93%, by percent volume, of the white-lipped peccary diet consisted of fruits and seeds (Figure 5-1). No crop species were recorded for the three white-lipped peccaries.

A total of 38 food items were recorded for the collared peccary (n = 29 stomachs; total volume analyzed = 1829.0 ml; Appendix R). By percent occurrence, the most frequent food items were fruits/seeds, leaves, and stems/roots from *Psychotria* sp. at 79.3% and fruits/seeds from *Brosimum alicastrum* at 75.9%. By percent volume, *Psychotria* sp. at 23.8% was the most commonly taken food item. Plant material composed 100.0% (32 taxa), by percent volume, of collared peccary stomach contents, while animal material composed < 0.0% (trace amounts of five taxa). About 58%, by percent volume, of the collared peccary diet consisted of fruits and seeds, while 21% consisted of items categorized as other, and 20% consisted of leaves (Figure 5-1). By percent volume, crop species (four taxa: squash, corn, sweet potato, and zacate) composed a total of 25.5% of the stomach contents.

For the brocket deer, a total of 32 food items were recorded (n = 8 stomachs; total volume analyzed = 446.0 ml; Appendix S). The most frequent food items were fruits/seeds, leaves, and stems/roots from *Psychotria* sp. at 87.5%, fruits/seeds and leaves from *Brosimum alicastrum* at 62.5%, leaves from *Eugenia* sp. (Myrtaceae) at 50.0%, and fruits/seeds from an unidentified plant at 50.0%, by percent occurrence. *Psychotria* sp. at 58.3%, by percent volume, was the most commonly taken food item. By percent volume, plant material composed 100.0% (30 taxa) of brocket deer stomach contents, while animal material composed < 0.0% (trace amounts of one taxon). About 42%, by percent volume, of the brocket deer diet consisted of leaves, while 33% consisted of fruits and seeds, and 25% consisted of items categorized as other (Figure 5-1). The single crop species zacate composed a total of 0.2%, by percent volume, of the stomach contents.

A total of 43 food items were recorded for the white-tailed deer (n = 11 stomachs; total volume analyzed = 601.0 ml; Appendix T). By percent occurrence, the most frequent food item was leaves and stems/roots from *Psychotria* sp. at 72.7%. By percent volume, *Psychotria* sp. at 42.7% was the most commonly taken food item. Plant material composed 100.0% (40 taxa), by percent volume, of white-tailed deer stomach contents, while animal material composed < 0.0% (trace amounts of two taxa). About 57%, by percent volume, of the white-tailed deer diet consisted of leaves, while 25% consisted of items categorized as other, and 18% consisted of fruits and seeds (Figure 5-1). By percent volume, the single crop species kidney bean composed a total of 9.0% of the stomach contents.

For the thicket tinamou, a total of seven food items were recorded (n = 3 stomachs; total volume analyzed = 13.0 ml; Appendix U). The most frequent food items were fruits/seeds from an unidentified plant at 100.0%, *Chrysophyllum mexicanum* (Sapotaceae) at 66.7%, and fruits/seeds from *Galactia striata* (Leguminosae) at 66.7%, by percent occurrence. The unidentified plant at 69.2%, by percent volume, was the most commonly taken food item. By percent volume, plant material composed 96.2% (six taxa) of thicket tinamou stomach contents, while animal material composed 3.8% (one taxon). About 96%, by percent volume, of the thicket tinamou diet consisted of fruits and seeds (Figure 5-1). The single crop species zacate composed a total of < 0.0% (trace amounts), by percent volume, of the stomach contents.

A total of 26 food items were recorded for the great curassow (n = 13 stomachs; total volume analyzed = 694.0 ml; Appendix V). By percent occurrence, the most frequent food items were plastic, rocks, and soil at 61.5%; fruits/seeds from *Diospyros* sp. (Ebenaceae) at 53.8%; and fruits/seeds from *Manilkara zapota* at 53.8%. By percent volume, *Brosimum alicastrum* at 34.5% was the most commonly taken food item. Plant material composed 98.5% (23 taxa), by percent volume, of great curassow stomach contents, while animal material composed < 0.0% (trace amounts of two taxa). About 95%, by percent volume, of the great curassow diet consisted of fruits and seeds (Figure 5-1). By percent volume, crop species (three taxa: kidney bean, squash, and zacate) composed a total of 4.2% of the stomach contents.

For the plain chachalaca, a total of 20 food items were recorded (n = 21 stomachs; total volume analyzed = 329.5 ml; Appendix W). The most frequent food items were fruits/seeds and leaves from *Chrysophyllum mexicanum* at 23.8% and fruits/seeds from *Metopium brownei* (Anacardiaceae) at 23.8%, by percent occurrence. *Metopium brownei* at 69.2%, by percent volume, and *Sabal yapa* (Palmae) at 17.9% were the two most commonly taken food items. By percent volume, plant material composed 100.0% (20 taxa) of plain chachalaca stomach contents, while animal material was not recorded. About 86%, by percent volume, of the plain chachalaca diet consisted of fruits and seeds (Figure 5-1). The single crop species zacate composed a total of 6.7%, by percent volume, of the stomach contents.

For the ocellated turkey, a total of 17 food items were recorded (n = 5 stomachs; total volume analyzed = 211.5 ml; Appendix X). The most frequent food items at 60.0% each by percent occurrence were fruits/seeds and leaves from zacate; leaves from *Psychotria* sp.; plastic, rocks, and soil; and fruits/seeds from an unidentified plant. Corn at 24.6%, kidney bean at 18.9%, and *Manilkara zapota* at 12.5%, by percent volume, were the three most commonly taken food items. By percent volume, plant material composed 92.9% (15 taxa) of ocellated turkey stomach contents, while animal material composed 3.8% (one taxon). About 68%, by percent volume, of the ocellated turkey diet consisted of fruits and seeds, while 25% consisted of leaves (Figure 5-1). Crop species (three taxa: zacate, corn, and kidney bean) composed a total of 51.1%, by percent volume, of the stomach contents.

In summary, the 11 game species consumed collectively a total of 86 plant taxa (80 noncrop species and 6 crop species [sweet potato, squash, yuca, corn, kidney bean, and zacate]), 25 animal taxa, and one "taxon" that consisted of plastic, rocks, and soil. The average number of food items per game species was 27.1 taxa (SE = 3.8, n = 11 game species, range = 7-49 food items per game species). By percent volume, plant matter (primarily fruits and seeds) composed 92-100% each of the diet for each species. The coati consumed the greatest proportion of animal matter at 8%, by percent volume. The average number of crop taxa per game species was 2.1 taxa (SE = 0.5, n = 11 game species, range = 0-4 crops per game species).

Crop Species Consumed by Game Species

Empty stomachs. Not all of the stomachs obtained from harvested wild animals contained food. A total of 22 individuals (ca. 4% of 584 game animals taken) had empty stomachs at the time they were taken (Table 5-2). Coatis had the greatest number of empty stomachs at 14 (ca. 8% of 167 individuals), while no empty stomachs were reported for seven game taxa.

Major crop species. Many of the main crop species were not consumed by game species. Of the 13 main crop species planted by gardeners (Table 5-1), seven taxa were not recorded in the stomach contents of game species, and will not be considered here further: yam, chaya, lentil, jícama, ib bean, chili, and fruits. For purposes of this chapter, the remaining six crop species will be renamed here as major crop species and will form the basis for the following discussion: sweet potato, squash, yuca, corn, kidney bean, and other/zacate.

Among the major crop species, corn and squash were the two most frequent taxa in the stomachs of game species with food, by percent occurrence, at 25% and 6%, respectively (n = 284 stomachs analyzed; Table 5-2). Zacate (taken by 7 of 11 game species) and corn (taken by 5 of 11 game species) were the major crop species most widely taken by game species.

The number of crop taxa in stomach contents of game species varied by game taxon (Table 5-2). The paca, agouti, and collared peccary consumed the greatest number of crop taxa, at four each, whereas the white-lipped peccary consumed no crop taxon and the coati, brocket deer, white-tailed deer, thicket tinamou, and plain chachalaca consumed a single crop taxon each.

The percent occurrence of major crop species in stomach contents of game species varied by taxon (Table 5-2). The ocellated turkey had the highest percent occurrence of major crop species at 80% (n = 5 stomachs), followed by the agouti (percent occurrence = 50%, n = 26 stomachs analyzed), paca (percent occurrence = 42%, n = 36 stomachs analyzed), and coati (percent occurrence = 40%, n = 129 stomachs analyzed). Overall, 35% of the stomachs that were not empty contained at least one major crop species.

Table 5-2. Percent occurrence of major crop species in the stomach contents of game species (n = 284 stomach contents analyzed; total volume analyzed = 12,064.1 ml) during June 1989-October 1990, excluding the pocket gopher.

Major crop species[b]	Game species[a]											% Total
	Apa	Dpu	Nna	Tpe	Tta	Mam	Ovi	Cci	Cru	Ove	Aoc	
Corn	25.0	23.1	40.3		10.3						40.0	25.4
Squash	22.2	15.4			13.8				7.7			6.0
Other/Zacate[c]		3.8			3.4	12.5		33.3	7.7	4.8	60.0	3.2
Sweet potato	2.8	15.4			10.3							2.8
Kidney bean							9.1		15.4		20.0	1.4
Yuca	2.8											0.3
Number of crop species	4	4	1	0	4	1	1	1	3	1	3	
Number of stomachs analyzed	36	26	129	3	29	8	11	3	13	21	5	284
Percent stomachs with ≥ 1 crop species	41.7	50.0	40.3	0.0	24.1	12.5	9.1	33.3	30.8	4.8	80.0	34.9
Number of empty stomachs	0	4	14	0	1	0	0	0	0	3	0	22

[a] Game species based on hunting inventory (see Chapter 3). Abbreviations: Apa = *Agouti paca*, Dpu = *Dasyprocta punctata*, Nna = *Nasua nasua*, Tpe = *Tayassu pecari*, Tta = *Tayassu tajacu*, Mam = *Mazama americana*, Ovi = *Odocoileus virginianus*, Cci = *Crypturellus cinnamomeus*, Cru = *Crax rubra*, Ove = *Ortalis vetula*, and Aoc = *Agriocharis ocellata*.

[b] Main crop species based on garden survey (see Chapter 6). Seven of the 13 main crop species did not occur in the stomach contents of game species and were excluded. The remaining six main crop species were designated as "major crop species."

[c] The term "other/zacate" refers primarily to zacate (*Scleria lithosperma*), but also includes an unidentified bean (*Phaseolus* sp.), an unidentified squash (*Cucurbita* sp.), and cucumber (*Cucumis* sp.). Among these crop species, only zacate was consumed by game species.

Seasonal Variation in Plant Parts Consumed by Game Species

Among the major crop species, the primary plant parts consumed were fruits and seeds (Table 5-3). However, game species also consumed tubers (e.g., sweet potato), roots (e.g., yuca), and leaves (e.g., kidney bean and zacate).

The data suggested that there were seasonal differences in the frequency at which the different plant parts were consumed. Fruits and seeds primarily were consumed during two seasons: (1) plant and weed and (2) weed and harvest. Leaves and plant parts categorized as other, however, primarily were consumed during the season called clear and burn. Due to small sample sizes, it was not possible to test for seasonal differences in consumption by plant part.

Selected Game Species

Not all game species at X-Hazil Sur consumed substantial amounts of crop species. This suggests that many game species obtained at least some of their food from the forest and were not dependent upon garden crops for food. For example, no crop species were recorded for stomach contents of the white-lipped peccary (n = 3 stomachs; Table 5-2). Further, of the 11 game species (excluding pocket gophers; Table 5-1), four taxa (coati, brocket deer, white-tailed deer, thicket tinamou, and plain chachalaca) consumed only a single crop species each. Except for the coati, which consumed a substantial amount of corn, the contribution of crops to the diets of the remaining three game species was relatively minor. For this reason, these game species were not included in the remaining analyses. In addition, the recorded consumption of crop species by the great curassow (n = 13 crop/gizzard samples) and the ocellated turkey (n = 5 crop/gizzard samples) were based on small sample sizes. In order to focus primarily on those game species that frequently ate crops, except for the coati, which consumed substantial amounts of corn, these seven species will not be considered here further. For purposes of this chapter, the remaining four game species (paca, agouti, coati, and collared peccary) will be renamed here as selected game species and will form the basis for the following discussion.

Table 5-3. Seasonal occurrence of major crop species in the stomach contents of game species (n = 284 stomach contents analyzed, total volume analyzed = 12,064.1 ml) during June 1989-October 1990, excluding the pocket gopher.

	Garden season[a]								
	Clear and burn (Jan-Apr)			Plant and weed (May-Aug)			Weed and harvest (Sep-Dec)		
Major crop species[b]	Plant parts[c]	No. stom.[d]	Volume (ml)[e]	Plant parts	No. stom.	Volume (ml)	Plant parts	No. stom.	Volume (ml)
Corn	100.0% FS < 0.0% O	7	148.0	100.0% FS < 0.0% O	4	56.0	100.0% FS	62	3174.5
Squash	100.0% FS	4	77.5	100.0% FS	7	214.0	100.0% FS	6	256.0
Other/Zacate[f]	< 0.0% FS 100.0% L	3	2.0	100.0% FS	3	25.0	93.3% FS 6.7% L	3	15.0
Sweet potato	70.5% FS 29.5% O	2	112.0						
Kidney bean	67.5% FS 32.5% L	4	123.0						
Yuca	100.0% O	1	54.0						
Total volume analyzed (ml)			3206.1			3033.5			5824.5
Total number stomachs analyzed		84			70			130	

[a] Garden season categories based on weather, garden activities, timber harvest, and *chicle* tapping (see text for additional information).
[b] See text and Table 5-2 for a description of major crop species.
[c] Percent volume of plant parts, by season, all game species combined. FS = fruits and seeds, L = leaves, and O = other (see text for additional information).
[d] Number of stomachs in which the major crop species occurred, by season, all game species combined.
[e] Total volume of stomach contents, by season, all game species combined.
[f] See Table 5-2 for additional information about the category "Other/Zacate."

Seasonal Variation in Consumption of Major Crop Species by Selected Game Species

The proportion of major crop species in the stomach contents of selected game species varied by season. The paca consumed four major crop species and exhibited seasonal differences in the proportion of these taxa in the diet, by percent volume (Table 5-4). For example, during the weed and harvest season, 64% of the stomach contents were major crop species (three taxa: primarily corn [33% by percent volume], squash [25% by percent volume], and sweet potato [7% by percent volume]). During the other two seasons, major crop species represented about 18-20% of the stomach contents (one-two taxa), by percent volume.

The agouti consumed four major crop species per season and exhibited seasonal differences in the proportion of these taxa in the diet, by percent volume (Table 5-4). For example, during the weed and harvest season, 68% of the stomach contents were major crop species (three taxa: primarily corn [52% by percent volume], squash [16% by percent volume], and other/zacate). During the clear and burn season, agoutis primarily consumed sweet potatoes (27% by percent volume) and corn (15% by percent volume), while during the plant and weed season, agoutis primarily consumed sweet potatoes (33% by percent volume) and squash (22% by percent volume).

The coati consumed a single major crop species, corn, during two of the three seasons and exhibited seasonal differences in the proportion of this taxon in the diet, by percent volume (Table 5-5). During the weed and harvest season, 66% by percent volume of the stomach contents were corn, while during the plant and weed season corn represented 16% by percent volume of the stomach contents. No major crop species were consumed by the coati during the clear and burn season.

The collared peccary consumed four taxa of major crop species and exhibited seasonal differences in the proportion of these taxa in the diet, by percent volume (Table 5-5). During the weed and harvest season, 41% by percent volume of the stomach contents were major crop species, primarily corn (41% by percent volume). During the plant and weed season, 23% by percent volume of the stomach contents were major crop species, primarily sweet potatoes (12% by percent volume) and

Table 5-4. Seasonal variation of major crop species in (a) paca stomach contents ($\underline{n}$ = 36 stomach samples, total volume analyzed = 1886.5 ml) and (b) agouti stomach contents ($\underline{n}$ = 26 stomach samples, total volume analyzed = 1167.5 ml), expressed as percent occurrence (% Occ.) and volume (% Vol.).

Major crop species[b]	Garden season[a]					
	Clear and burn (Jan-Apr)		Plant and weed (May-Aug)		Weed and harvest (Sep-Dec)	
	% Occ.[c]	(% Vol.)[d]	% Occ.	(% Vol.)	% Occ.	(% Vol.)
a) Paca						
Corn	15.0	(5.2)	0.0	(0.0)	42.9	(32.5)
Squash	15.0	(7.5)	100.0	(20.2)	21.4	(24.5)
Sweet potato	0.0	(0.0)	0.0	(0.0)	7.1	(6.9)
Yuca	5.0	(5.2)	0.0	(0.0)	0.0	(0.0)
Volume (ml)		(1034.1)		(124.0)		(728.0)
No. stomachs	20		2		14	
b) Agouti						
Corn	22.2	(14.5)	11.1	(1.5)	37.5	(51.5)
Squash	0.0	(0.0)	22.2	(20.5)	25.0	(16.1)
Other/ Zacate	0.0	(0.0)	0.0	(0.0)	12.5	(< 0.0)
Sweet potato	11.1	(27.3)	33.3	(39.8)	0.0	(0.0)
Volume (ml)		(289.0)		(394.5)		(484.0)
No. stomachs	9		9		8	

[a] See text for additional information about the three garden season categories.
[b] See text and Table 5-2 for additional information about how the "major crop species" were determined. For the paca, kidney bean and other/zacate did not occur in stomach contents. For the agouti, yuca and kidney bean did not occur in stomach contents.
[c] Percent occurrence in stomach contents, by garden season.
[d] Percent volume in stomach contents, by garden season.

Table 5-5. Seasonal variation of major crop species in (a) coati stomach contents ($\underline{n}$ = 129 stomach samples, total volume analyzed = 4678.5 ml) and (b) collared peccary stomach contents ($\underline{n}$ = 29 stomach samples, total volume analyzed = 1829.0 ml), expressed as percent occurrence (% Occ.) and volume (% Vol.).

Major crop species[b]	Garden season[a]					
	Clear and burn (Jan-Apr)		Plant and weed (May-Aug)		Weed and harvest (Sep-Dec)	
	% Occ.[c]	(% Vol.)[d]	% Occ.	(% Vol.)	% Occ.	(% Vol.)
a) Coati						
Corn	0.0	(0.0)	7.7	(16.2)	54.3	(66.0)
Volume (ml)		(652.0)		(309.0)		(3717.5)
No. stomachs	22		13		94	
b) Collared peccary						
Sweet potato	0.0	(0.0)	11.1	(11.9)	12.5	(< 0.0)
Squash	0.0	(0.0)	16.7	(10.7)	12.5	(< 0.0)
Corn	0.0	(0.0)	5.6	(< 0.0)	25.0	(40.9)
Other/ Zacate	0.0	(0.0)	5.6	(0.3)	0.0	(0.0)
Volume (ml)		(241.0)		(1013.0)		(575.0)
No. stomachs	3		18		8	

[a] See text for additional information about the three garden season categories.
[b] See text and Table 5-2 for additional information about how the "major crop species" were determined. For the coati, sweet potato, squash, yuca, kidney bean, and other/zacate did not occur in stomach contents. For the collared peccary, yuca and kidney bean did not occur in stomach contents.
[c] Percent occurrence in stomach contents, by garden season.
[d] Percent volume in stomach contents, by garden season.

squash (11% by percent volume). No major crop species were consumed by the collared peccary during the clear and burn season.

In summary, only a subset of the main crops were consumed in substantial quantities by game species. These were the sweet potato, squash, yuca, corn, kidney bean, and other/zacate. In addition, only a subset of the game species consumed substantial quantities of crop species. These were the paca, agouti, coati, and collared peccary.

Discussion

According to Linares (1976), the practice of garden hunting is based on the fact that certain species of terrestrial mammals are tolerant of human disturbances and feed regularly on cultivated crops. Since these species congregate in areas with cultivated crops, the biomass of these game animals is greater in the vicinity of the gardens than in the adjacent forest. This increased biomass of wild animals, according to Linares (1976), supports a game-procurement system by human hunters that exploits the diet and behavioral characteristics of these mammals.

The results obtained during this study confirmed that many game species consumed crops, as well as other plant and animal matter. In the first part of this discussion, I will generally describe game food habits at Ejido X-Hazil y Anexos, compare them with food habits reported for other areas, and summarize briefly the behavior and ecology of game species as they relate to food habits. In the second part, I will describe the percent frequency and occurrence of crop species in game diets. In the third part, I will discuss seasonal variation in crop consumption by game species. In conclusion, I will suggest that crops and gardens are important food sources for game species at Ejido X-Hazil y Anexos but that noncrop species also are important to game animals.

Food Items Consumed by Game Species

Pacas are nocturnal frugivore-granivores (Eisenberg, 1981). They are not especially social animals and usually live alone (Collett, 1981; Leopold, 1977). Pacas are found in a variety of habitat types, but usually seek forested areas near water (Grimwood, 1969; Matamoros H., 1982; Nowak and Paradiso, 1983). On the Yucatán Peninsula, pacas reportedly do not dig burrows (Hall and Dalquest, 1963; Leopold, 1977), but burrow digging has been noted in other areas (Baker, 1974).

At Ejido X-Hazil y Anexos, plant material (primarily fruits and seeds) composed 99.8% (23 taxa reported), by percent volume, of paca stomach contents, whereas animal material composed 0.2% (five taxa reported). A total of 28 taxa of food items were reported (Figure 5-1; Appendix N). Among mammals at Ejido X-Hazil y Anexos, pacas ranked second among seven taxa (excluding pocket gophers) in percent volume of fruits and seeds in the diet and ranked fifth in the total number of taxa of food items consumed. Elsewhere, the diet consists of leaves, stems, roots, seeds, and fallen fruits (especially avocados and mangos) (Chávez León, 1983; Nowak and Paradiso, 1983; Smythe et al., 1982).

Agoutis are diurnal frugivore-granivores (Eisenberg, 1981; Smythe, 1983). They are social animals and usually occur as a mated pair (Smythe, 1978). Agoutis live closely associated with water and are found in forests, thick brush, savannahs, and cultivated areas (Grimwood, 1969; Nowak and Paradiso, 1983). Agoutis, unlike pacas, do not dig burrows. Agoutis, however, cache fruits and seeds during periods of food abundance and retrieve those items when food is scarce (Murie, 1977).

At Ejido X-Hazil y Anexos, plant material (primarily fruits and seeds) composed 99.9% (19 taxa reported), by percent volume, of agouti stomach contents, whereas animal material composed 0.1% (two taxa reported). A total of 21 taxa of food items were reported (Figure 5-1; Appendix O). Among mammals at Ejido X-Hazil y Anexos, agoutis ranked first among seven taxa in percent volume of fruits and seeds in the diet and ranked sixth in the total number of taxa of food items consumed. Elsewhere, the diet consists of fruits, vegetables, and succulent plants (Chávez León, 1983; Hallwachs, 1986; Nowak and Paradiso, 1983; Smythe, 1983; Smythe et al., 1982).

Coatis are diurnal frugivore-omnivores (Eisenberg, 1981), but adult males may forage at night. Primarily frugivores when fruits are available, coatis instead consume rodents and invertebrates during times when fruits are scarce (Smythe, 1970). While adult male coatis usually are solitary, adult females and their young are highly social and occur in large groups that on Barro Colorado Island had 4-20 individuals (Kaufmann, 1962; Smythe, 1970; Russell, 1981). Coatis are found in wooded areas and forage in trees, as well as on the ground (Kaufmann, 1983; Kaufmann et al., 1976; Nowak and Paradiso, 1983).

At Ejido X-Hazil y Anexos, plant material (primarily fruits and seeds) composed 91.6% (29 taxa reported), by percent volume, of coati stomach contents, whereas animal material composed 8.4% (19 taxa reported). A total of 49 taxa of food items were reported (Figure 5-1; Appendix P). Among mammals at Ejido X-Hazil y Anexos, coatis ranked fourth among seven taxa in percent volume of fruits and seeds in the diet and ranked first in the total number of taxa of food items consumed. At 8.4% by percent volume, coatis ranked first among seven taxa in the proportion of animal material in the diet. Elsewhere, the diet consists of both plant and animal matter (Bisbal E., 1986; Chávez León, 1983; Nowak and Paradiso, 1983).

White-lipped peccaries are nocturnal frugivore-herbivores (Eisenberg, 1981). They are highly social and can occur in large groups of several hundred individuals (Kiltie and Terborgh, 1983; Leopold, 1977; Sowls, 1983, 1984). White-lipped peccaries occupy large home ranges and are found in several habitat types, including desert scrub, arid woodlands, and rain forest (Donkin, 1985; Grimwood, 1969; Nowak and Paradiso, 1983). These peccaries frequent waterholes.

At Ejido X-Hazil y Anexos, plant material (primarily fruits and seeds) composed 100.0% (14 taxa reported), by percent volume, of white-lipped peccary stomach contents, whereas animal material composed < 0.0% (trace amounts of three taxa reported). A total of 17 taxa of food items were reported (Figure 5-1; Appendix Q). Among mammals at Ejido X-Hazil y Anexos, white-lipped peccaries ranked third among seven taxa in percent volume of fruits and seeds in the diet and ranked seventh in the total number of taxa of food items consumed. Elsewhere, the diet consists of cactus fruit, berries, tubers, bulbs, rhizomes, grubs, snakes, and small vertebrates (Donkin, 1985; Kiltie, 1981; Nowak and Paradiso, 1983; Sowls, 1984).

Collared peccaries, like white-lipped peccaries, are nocturnal frugivore-herbivores (Eisenberg, 1981). These peccaries are highly social but occur in smaller groups than do white-lipped peccaries. Group size ranges from 2-50, but usually is 5-15 individuals (Castellanos, 1983; Donkin, 1985; Nowak and Paradiso, 1983; Robinson and Eisenberg, 1985). Collared peccaries occupy large home ranges and, like white-lipped peccaries, are found in scrub, woodlands, and forest (Bigler, 1974; McCoy et al., 1990; Schweinsburg, 1971; Sowls, 1974, 1978, 1983, 1984).

At Ejido X-Hazil y Anexos, plant material (primarily fruits and seeds) composed 100.0% (32 taxa reported), by percent volume, of collared peccary stomach contents, whereas animal material composed < 0.0% (trace amounts of five taxa reported). A total of 38 taxa of food items were reported (Figure 5-1; Appendix R). Among mammals at Ejido X-Hazil y Anexos, collared peccaries ranked second among seven taxa in percent volume of fruits and seeds in the diet and ranked third in the total number of taxa of food items consumed. Elsewhere, the diet consists of fruits, berries, tubers, bulbs, rhizomes, grubs, snakes, vegetables, and small vertebrates (Chávez León, 1983; Day, 1986; Donkin, 1985; Kiltie, 1981; McCoy et al., 1983; Nowak and Paradiso, 1983; Sowls, 1984).

Brocket deer are frugivore-herbivores (Eisenberg, 1981). Diurnal, nocturnal, and crepuscular activity has been reported (Nowak and Paradiso, 1983). These deer are solitary, except during the mating season. Brocket deer are shy, sedentary, and are found in woodlands and forests (Chávez León, 1983).

At Ejido X-Hazil y Anexos, plant material (primarily leaves) composed 100.0% (30 taxa reported), by percent volume, of brocket deer stomach contents, whereas animal material composed < 0.0% (trace amounts of one taxon reported). A total of 32 taxa of food items were reported (Figure 5-1; Appendix S). Among mammals at Ejido X-Hazil y Anexos, brocket deer ranked sixth among seven taxa in percent volume of fruits and seeds in the diet and ranked fourth in the total number of taxa of food items consumed. At ca. 42% by percent volume, brocket deer ranked second in the proportion of leaves in the diet. Elsewhere, the diet consists of grasses, vines, and tender green shoots (Nowak and Paradiso, 1983). In Suriname (Branan et al., 1985), red brocket deer rumens contained food material from at least 57 plant species (n = 75 rumens collected during 8 months), whereas for white-tailed deer, only 14 plant species were identified (n = 13 rumens).

White-tailed deer are crepuscular herbivore-browsers (Eisenberg, 1981). These deer are social, but two different types of groups have been reported. Adult males are solitary or occur in small groups with other males, whereas adult females occur in groups with their yearling daughter and fawns of the year (Marchington and Hirth, 1984). White-tailed deer are found in a great variety of habitat types, but they avoid dense forests (Nowak and Paradiso, 1983).

At Ejido X-Hazil y Anexos, plant material (primarily leaves) composed 100.0% (40 taxa reported), by percent volume, of white-tailed deer stomach contents, whereas animal material composed < 0.0% (trace amounts of two taxa reported). A total of 43 taxa of food items were reported (Figure 5-1; Appendix T). Among mammals at Ejido X-Hazil y Anexos, white-tailed deer ranked seventh among seven taxa in percent volume of fruits and seeds in the diet and ranked second in the total number of taxa of food items consumed. At ca. 57% by percent volume, white-tailed deer ranked first in the proportion of leaves in the diet. Elsewhere, the diet consists of grasses, weeds, shrubs, twigs, mushrooms, nuts, lichens, vegetables, and vegetable leaves (Chávez León, 1983; Mandujano and Rico-Gray, 1991; Nowak and Paradiso, 1983; Vaughan and Rodriguez, 1991). At Ejido X-Hazil y Anexos, unlike in Suriname, brocket deer (32 taxa reported) and white-tailed deer (43 taxa reported) consumed about the same number of plant taxa.

Thicket tinamous are diurnal frugivore-granivores that forage on the ground (Paynter, 1955a, 1955b; Slud, 1964). They are not especially social and usually occur as solitary individuals (Delacour and Amadon, 1973). Thicket tinamous are found in dry woodlands, especially along forest edges, but seldom enter open areas (Leopold, 1977). Tinamous do not scratch for food with their feet (Lancaster, 1983).

At Ejido X-Hazil y Anexos, plant material (primarily fruits and seeds) composed 96.2% (six taxa reported), by percent volume, of thicket tinamou stomach contents, whereas animal material composed 3.8% (one taxon reported). A total of 32 taxa of food items were reported (Figure 5-1;

Appendix U). Among birds at Ejido X-Hazil y Anexos, thicket tinamous ranked first among four taxa in percent volume of fruits and seeds in the diet and ranked fourth in the total number of taxa of food items consumed. Elsewhere, the diet consists of seeds, fruits, and insects (Chávez León, 1983; Lancaster, 1983).

Great curassows are diurnal frugivore-herbivores that forage on the ground (Karr et al., 1990; Paynter, 1955a, 1955b; Slud, 1964). They occur individually or in small groups (Delacour and Amadon, 1973). Primarily terrestrial, great curassows are found in ravines, shrubby areas, and humid woodlands (Amadon, 1983; MacKinnon Vda. de Montes, 1989).

At Ejido X-Hazil y Anexos, plant material (primarily fruits and seeds) composed 98.5% (23 taxa reported), by percent volume, of great curassow stomach contents, whereas animal material composed < 0.0% (trace amounts of two taxa reported). A total of 26 taxa of food items were reported (Figure 5-1; Appendix V). Among birds at Ejido X-Hazil y Anexos, great curassows ranked second among four taxa in percent volume of fruits and seeds in the diet and ranked first in the total number of taxa of food items consumed. Elsewhere, the diet consists of fruits, seeds, succulent leaves, and insects (Amadon, 1983; Chávez León, 1983; Méndez, 1979).

Plain chachalacas are diurnal frugivore-herbivores that forage on then foliage in the canopy (Paynter, 1955a, 1955b; Slud, 1964). They are social and usually occur in small groups (Delacour and Amadon, 1973). Primarily arboreal, plain chachalacas are found in a variety of dry habitat types, including fallow areas, agricultural fields, and forest edges (Leopold, 1977; MacKinnon Vda. de Montes, 1989; Slud, 1964).

At Ejido X-Hazil y Anexos, plant material (primarily fruits and seeds) composed 100.0% (20 taxa reported), by percent volume, of plain chachalaca stomach contents, whereas animal material was not reported. A total of 20 taxa of food items were reported (Figure 5-1; Appendix W). Among birds at Ejido X-Hazil y Anexos, plain chachalacas ranked third among four taxa in percent volume of fruits and seeds in the diet and ranked second in the total number of taxa of food items consumed. Elsewhere, the diet consists of fruits and seeds (Leopold, 1977).

Ocellated turkeys, endemic to Mexico, are diurnal frugivore-omnivores that forage on the ground (Paynter, 1955a, 1955b). They occur as solitary individuals or mated pairs. Ocellated turkeys are found in forested areas adjacent to fallow areas or agricultural fields (Leopold, 1977; MacKinnon Vda. de Montes, 1989).

At Ejido X-Hazil y Anexos, plant material (primarily fruits and seeds) composed 92.9% (15 taxa reported), by percent volume, of ocellated turkey stomach contents, whereas animal material composed 3.8% (one taxon reported). A total of 17 taxa of food items were reported (Figure 5-1; Appendix X). Among birds at Ejido X-Hazil y Anexos, ocellated turkeys ranked fourth among four taxa in percent volume of fruits and seeds in the diet and ranked third in the total number of taxa of food items consumed. Elsewhere, the diet consists of fruits, seeds, and insects (Leopold, 1977).

In summary, fruits and seeds were the primary food items at Ejido X-Hazil y Anexos for both birds and mammals, by percent occurrence and volume, for 9 of the 11 taxa analyzed (Figure 5-1). Among mammals, the paca, agouti, coati, and white-lipped peccary consumed relatively large proportions of fruits and seeds (≥ 92% by volume), while the collared peccary consumed a moderate proportion (58% by volume), and the brocket deer and white-tailed deer consumed relatively low proportions of fruits and seeds (33% and 18% by volume, respectively; Figure 5-1). The brocket deer and white-tailed deer, on the other hand, primarily consumed leaves (42% and 57% by volume, respectively). Among birds, all four taxa primarily consumed fruits and seeds (68-96% by volume). Animal material, primarily invertebrates, was important in the diet of three taxa; coati, thicket tinamou, and ocellated turkey. Food habits for game birds and mammals at Ejido X-Hazil y Anexos generally agree with those reported elsewhere.

Crop Species Consumed by Game Species

The consumption of crops is critical to the theory of garden hunting (Linares, 1976). Whereas Linares (1976) described garden hunting only with respect to terrestrial mammals, at Ejido X-Hazil y Anexos, both game birds and mammals consumed crops.

Six crops of the 13 planted by Maya gardeners at Ejido X-Hazil y Anexos were consumed by game species: corn, squash, other/zacate, sweet potato, kidney bean, and yuca (see Chapter 6). These species are among the most abundant crops by percent occurrence in gardens and number of stalks/m^2.

An analysis of crop consumption patterns by game species indicates that there are differences among game species. By percent volume of crops in game stomachs, the agouti (59.3%), coati (53.5%), and ocellated turkey (51.1%) ranked highest among game species. By percent occurrence of stomachs with ≥ one crop species, the ocellated turkey (80.0%), agouti (50.0%), paca (41.7%), and coati (40.3%), ranked highest among game species (Table 5-2). By number of crop taxa consumed, the paca (4 crop taxa), agouti (4), and collared peccary (4), ranked highest among game species. This shows that crops are relatively important to five taxa (paca, agouti, coati, collared peccary, and ocellated turkey), whereas crops are relatively unimportant to six taxa (white-lipped peccary, brocket deer, white-tailed deer, thicket tinamou, great curassow, and plain chachalaca).

A comparison of percent volume of crops in game stomachs and percent occurrence of kill sites in areas categorized as Combined/Early Secondary Forest (primarily gardens and fallow areas), shows that gardens may be important to some game species for reasons other than the availability of crops. Four taxa had relatively low consumption levels of crops and relatively high proportions of kill sites in areas categorized as Combined/Early Secondary Forest; brocket deer, white-tailed deer, thicket tinamou, and plain chachalaca; Figure 5-2). One possible reason for this is that these species could be ignoring crops, but feeding on plant or animal material that occurs in gardens and fallows. Another possible reason is that gardens and fallows may be important as nesting sites or for social interactions.

Seasonal Variation in Consumption of Major Crop Species by Selected Game Species

Crops are not equally available in gardens throughout the year. Depending upon when the seasonal rains begins, crops are planted during May-July (Figure 6-1). Crops are harvested during November-January, but this also depends upon the weather and the specific type of crop (see Chapter 6). Corn, for example, is harvested at this time, but squash and sweet potatoes may be left in the

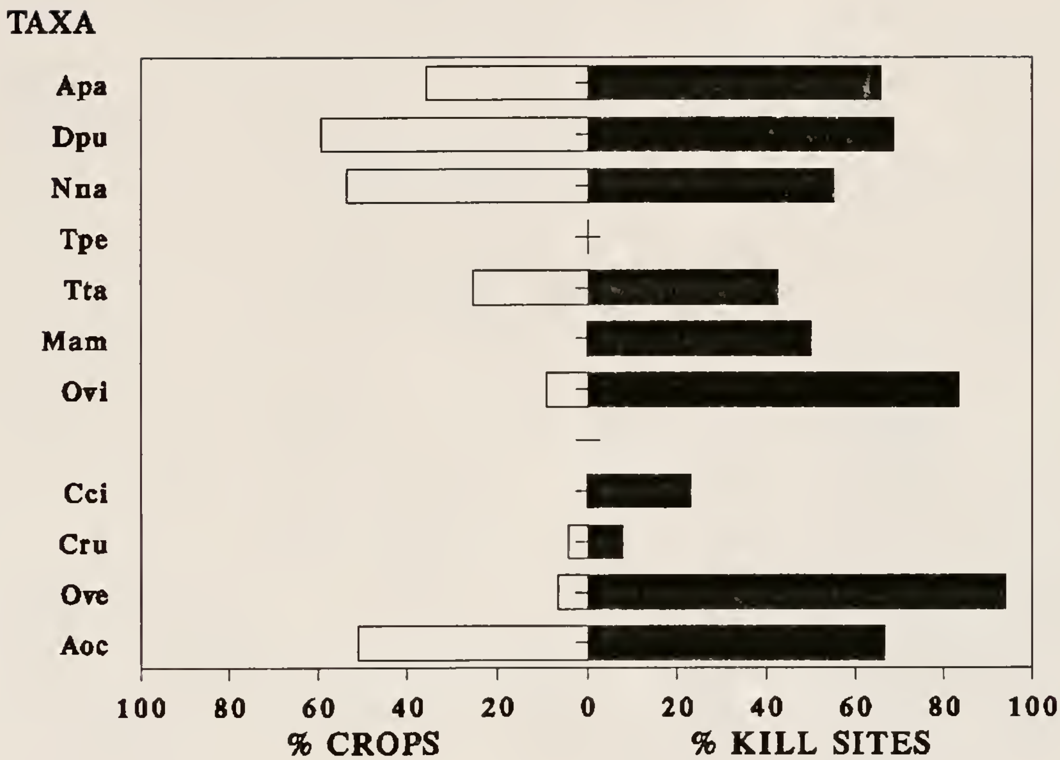

Figure 5-2. Percent volume of crops in game stomachs (n = 284 stomachs analyzed) and percent occurrence of kill sites in areas categorized as Combined/Early Secondary Forest (n = 584 game kills).

gardens for several additional months as they do not spoil quickly. Zacate, on the other hand, grows throughout the year.

Among major crop species, there were seasonal differences in the percent occurrence and volume of crops in stomach contents for all game species combined (Table 5-3). Three crop taxa were consumed only during a single garden season. The sweet potato, kidney bean, and yuca were consumed only during the clear and burn season, when mature plants, fruits, and seeds from the previous growing season were still available in the garden. Three crop taxa were consumed throughout the year; corn, squash, and other/zacate. The plant parts consumed of these three taxa, however, varied by season. Fruits and seeds of corn and squash were consumed throughout the year. Corn was available throughout the year for several reasons: One, some corn plants never were harvested due to garden failures. Two, some cobs were stored in huts near gardens, but crop predators raided these sites. Three, some corn germinated in fallow areas. Zacate leaves, however, were consumed during the clear and burn season while zacate fruits and seeds were consumed during the rest of the year.

Among selected game species, there were seasonal differences in the percent occurrence and volume of crops in stomach contents for the major crop species. For pacas, the major period of crop consumption was the weed and harvest season when corn (42.9% by occurrence and 32.5% by volume) and squash (21.4% by occurrence and 24.5% by volume; Table 5-4a) were the main crops consumed. For agoutis, the major period of crop consumption also was the weed and harvest season when corn (37.5% by occurrence and 51.5% by volume; Table 5-4b) was the main crop consumed. For coatis, the major period of crop consumption also was the weed and harvest season when corn (54.3% by occurrence and 66.0% by volume; Table 5-5a) was the only crop consumed. For collared peccaries, the major period of crop consumption also was the weed and harvest season when corn (25.0% by occurrence and 40.9% by volume; Table 5-5b) was the main crop consumed. While the consumption of other/zacate, sweet potatoes, kidney beans, and yuca by game species cannot be ignored, these data suggest that the consumption of crops by game species is primarily that of corn and squash during the weed and harvest season.

In conclusion, these data generally support the garden hunting hypothesis (Linares, 1976) by confirming that several species of game birds and mammals consume garden crops. These data indicate, however, that game species do not depend exclusively upon crops. For the 11 game taxa considered, on average at least 30% of the stomach contents were not crop species. In addition, crops largely were unavailable during four to eight months of the year. Given the seasonal nature of game kills, it was not always possible to determine game diets throughout the entire year. These data, however, show that crops are important to some game species at least part of the year.

CHAPTER 6
CHARACTERISTICS OF MAYA GARDENS AND THEIR USE
BY WILDLIFE IN QUINTANA ROO, MEXICO

Introduction

For the Maya today, as for the past 3,000-4,000 years, daily life is centered around their gardens and the production of corn, the principal crop (Redfield and Villa Rojas, 1962; Steggerda, 1941). A successful garden provides esteem to the gardener, as well as abundant food resources for the family and its domestic animals (e.g., cattle, pigs, chickens, or turkeys). In addition, a successful crop harvest is evidence to the gardener, as well as to other villagers, that he and his family have fulfilled their spiritual obligations to the numerous Mayan saints and spirits. Natural events such as crop failures or low crop yields, according to the Maya, have spiritual causes and require spiritual solutions (cf., Burns, 1983:202-225). In this sense, the garden has both a practical and a religious context (Villa Rojas, 1987).

Recognizing the importance of gardens to the Maya and other subsistence farmers in Latin America, much has been written about gardens and their characteristics (cf. Conklin, 1961; Ewell and Merrill-Sands, 1987; Watters, 1971). These studies suggest that the practice of gardening has changed little in the Yucatán Peninsula over the past 500 years (Hammond, 1982a, 1982b; Landa, 1978; Morley, 1956; Roys, 1972; Turner, 1974, 1990). These studies also give the impression that gardens are important only in terms of providing food to the Maya. Rewald (1989) and Greenberg (1992), however, suggest that Maya gardens and shifting cultivation might be part of a larger ecological process that is dynamic--rather than static--and affects both native plants and wildlife.

One important ecological process that has been affected by gardens and shifting cultivation is the distribution and abundance of many important plant species in the Yucatán Peninsula. For example, fruits such as *huaya* (*Talisia olivaeformis*; see comment in the Methods section about Maya and Spanish terms), *sak paj* (*Brysonima bucidaefolia*), and *mamey* (*Calocarpus mammosum*) are edible native plants that thrive in the early successional stages of the forests that regrow in fallowed garden sites (Edwards, 1986; Murphy, 1990; Puleston, 1982). In addition, sapodilla (*Manilkara zapota*), mahogany (*Swietenia macrophylla*), and cedar (*Cedrela odorata*) are valuable timber species that do not regrow quickly and are consequently spared from felling by the Maya when gardens are cleared (Rewald, 1989), whereas *copal* (*Protium copal*) and *ramón* (*Brosimum alicastrum*) may actually have been grown in plantations by the ancient Maya (Roys, 1972). These examples suggest that the ancient Maya had an extensive knowledge of useful plants in the forest and were able to manage these species during several hundred years.

By managing these useful plant species in coordination with their gardening practices, Maya gardeners created a habitat mosaic. This mosaic included gardens, fallow gardens, and managed forests of various sizes and many age classes in close proximity to one another. Given the length of Maya occupation of the Yucatán Peninsula (3,000-4,000 y) and the wide area over which shifting cultivation has been practiced by these people (Mexico, Belize, Guatemala, and Honduras), the present forests of the Yucatán Peninsula are considered by many scientists to be highly anthropogenic (Barrera et al., 1977; Edwards, 1986; Gómez-Pompa et al., 1987; Lundell, 1933).

In marked contrast to numerous studies on the impact of shifting cultivation on soils and plants (e.g., Noguez-Galvez, 1991; Nye and Greenland, 1960), the impact of shifting cultivation on the distribution and abundance of wildlife species in the Yucatán Peninsula, while discussed by some researchers, has not been thoroughly investigated. This deficiency is especially glaring given the importance, wide extent, and long history of subsistence hunting by the Maya (cf. Hamblin, 1984, 1985; Hamblin and Rea, 1985; Pohl, 1976, 1985; Reina, 1967; Wing and Steadman, 1980) and evidence that this hunting may be dependent upon shifting cultivation. From a slightly different perspective, this deficiency in garden studies is also serious because hunting yields by other indigenous people practicing shifting cultivation have been shown to be a function of settlement age (Vickers, 1980, 1988, 1991).

At least three studies have examined hunting with respect to gardens and shifting cultivation in Mesoamerica. Based on an archeological analysis of animal bones found in middens at Cerro Brujo, a forested area in northern Panama, Linares (1976) concluded that subsistence hunting by Cerro Brujo hunters was sustainable and conducted in accordance with ecological relationships that were exploited by these people. According to Linares (1976), the interspersion of small gardens in the forest around the settlement enhanced the populations of certain species of wildlife. The local wildlife populations were enhanced because they regularly fed on the crops planted in the gardens. Cerro Brujo hunters in turn exploited the increased wildlife populations. This relationship, called "garden hunting" by Linares (1976), described an association between hunters and prey that depends upon gardens. In garden hunting, the prey animal species, due to the garden, benefit from the additional food resources available, and the Cerro Brujo hunters, also because of the garden, benefit from the additional game available.

The beneficial relationship between wildlife and shifting cultivation also has been documented in contemporary studies beyond Panama. For example, the Lacandon Maya in southern Mexico practice garden hunting. Based upon an analysis of plant and wildlife use of gardens, fallowed gardens, and the surrounding forest, Nations and Nigh (1980:17) made two observations relevant to this chapter: "the *acahual* [fallowed garden] attracts many animals of interest to humans," and "the majority of the animals attracted to the *acahual* cannot live from that area alone; they must also complete critical periods of their life cycle in other environments." These observations reinforce Linares' (1976) hypothesis that the interspersion of gardens in forest has enhanced hunting and wildlife densities and has resulted in a dependent relationship between gardens and the populations of many wildlife species.

The present study was designed to test some of Linares' (1976) hypotheses by examining garden hunting in a forested area in southeastern Mexico that is populated by Maya Indians who practice subsistence hunting and shifting cultivation. Specifically, this study proposed to characterize Maya gardens and to quantify their use by wild animals. In designing this study about gardens and wildlife, several factors had to be considered: One, not all adult Maya *ejido* residents planted gardens every year. While all *ejido* members normally were required to plant a garden as one of several requirements to maintain their residency status, sometimes this regulation was not enforced (D. Ake Ayala, pers. comm.). Two, gardeners were free to select any site within the study area on which to plant their garden. The single exception to this was a 25,000 ha parcel of land declared as a permanent forest reserve by *ejido* and state forestry officials (M. Carreón Mundo, pers. comm.). Three, gardeners were free to determine the crops planted, the amount of land cleared, and the times to plant and harvest. Four, the distribution of roads, trails, fertile soil, and level lands appropriate for planting varied greatly on the study area. Five, gardeners often employed other workers or formed teams with friends or family members to complete garden-related tasks. Six, gardeners often undertook other activities (e.g., hunting, *chicle* tapping, and gathering firewood) while they were tending their gardens. These factors required that the study be carefully planned and the analyses carefully thought out.

There were three general objectives for this study and several specific hypotheses:

First objective.--Determine the total number of gardeners and number of gardens planted in 1989 by X-Hazil Sur residents and compare this with a subset of gardeners and gardens planted in 1990. The specific hypothesis tested was that there was no difference between 1989 and 1990 with respect to the number of gardens planted per "garden group" (see definition, below).

Second objective.--Describe the annual horticultural cycle, quantify garden characteristics, and characterize crop phenology, density, and mortality. The specific hypotheses tested were that there was no differences between 1989 and 1990 with respect to the following variables: garden size, distance from X-Hazil Sur, number of crops planted, and number of years of continuous use to which the garden had been subjected.

Third objective.--Characterize crop predation and wildlife use of gardens and adjacent forest. Three specific hypotheses were tested: One, there was no difference between wildlife use of track slicks in gardens and the adjacent forest in 1990. Two, there was no difference between wildlife use of Late Secondary Forest without Gardens (see definition, below), Late Secondary Forest with Gardens, and Early Secondary Forest in 1990 with respect to number of wildlife taxa reported and number of track sets recorded. Three, there was no difference among months in the occurrence of wildlife track sets in the track slicks.

Methods

Study Area

The study took place at Ejido X-Hazil y Anexos, Quintana Roo, Mexico, during 1989-1990 (total area = 552.95 km^2; Figure 2-1). Gardening data were obtained from residents at the village of X-Hazil Sur (19°23′30″N, 88°05′00″W; population = 1,040), the largest of three villages on the *ejido* (total population = 1,680). The mean annual temperature is about 26°C and the area typically has one dry season (December-May) and one wet season (June-November). Rainfall during 1 January-12 December 1990 was 1,277.3 mm (Figure 2-4). About 88.52% of the *ejido* was categorized as Late Secondary Forest, 6.07% as Plots & Gardens, 5.18% as Early Secondary Forest, and 0.23% as Other (Table 2-3). Since about 1915 the area has been occupied by Maya Indians, whose main subsistence activity has been shifting cultivation, primarily corn. Prior to 1915 the area was not inhabited by Maya Indians.

Gardener Interviews

During 1989 a complete census of X-Hazil Sur households was conducted in order to determine the number of residents who planted gardens and the characteristics of those gardens. Only limited information about the annual horticultural cycle was obtained at that time for two reasons: one, the villagers did not yet trust me, and two, the planting season already had passed and gardeners did not remember when specific garden activities were conducted. In 1990, a random sample of those who planted gardens in 1989 was selected and interviewed to enable comparisons about gardening between years. The 1990 interviews were more successful and included additional questions about the annual horticultural cycle that were not asked in 1989 (e.g., dates of clearing and burning). Interviews usually were conducted at the home of the gardener (see Appendix Y for a copy of the data form). A local

Maya assistant translated or explained the questions, if necessary, during the 15 min interview. Questions were asked in Spanish or Maya.

If all gardens were the same in the sense that each household planted a single garden, then it would be expected that the relationship between all gardens and wildlife would be comparable. However, if some households shared in planting gardens or if outside labor was used, then the relationship between gardens and wildlife might be different. Originally it was thought that each adult man would plant a garden by himself for his immediate family. This would result in a certain duration of work and frequency of visits to the garden site. During the gardener interviews, however, it became apparent that this single pattern was not universally applicable at X-Hazil Sur and that there were various arrangements by which gardens were planted and the crops harvested and distributed. These differences potentially could affect wildlife use of gardens by substantially decreasing the rate at which workers visited the garden.

Another reason for not summarizing garden activities per household was because nonfamily members often cooperated in garden activities. For example, an adult man could individually have a single garden for the use of his immediate family, or he could share the work and the crop obtained with a son, brother, or other relative. In other cases, two men might cooperate in planting one garden, while individually planting other gardens. These arrangements changed during the growing season and between years as gardeners died, became ill, or took temporary jobs outside of the *ejido*. As a result, there was a great deal of flexibility regarding who worked in the garden and who shared in the harvest. This complex situation suggested that a new term should be used to described the gardening unit.

In this chapter, instead of trying to categorize and quantify the different gardening arrangements, the single term *garden group* will be used to denote all of the people, except temporary contract employees, who contributed to the production or consumption of garden crops from a particular garden. Garden group is different from the term *household* in that garden group members may not necessarily be related or eat or sleep in the same housing compound. Garden group is similar to household in that members have a close economic and social relationship. Garden group thus recognizes that gardeners may or may not be related and may or may not live together as a family unit.

During this study, *garden* was used for the Spanish term *milpa* to identify the plot of land away from the house compound where crops such as corn were planted. Milpas are different from *solares*, which are located within the house compound and include a great variety of important annual and perennial plants (Forrest, 1991).

Soil Type of Gardens and Transects

Soil type is an important factor in determining the potential crop production of a garden. In addition, soil type will determine, in part, the type of forest that regenerates in a garden placed in fallow. Soil type was determined by a local forester for the seven selected gardens (garden numbers 5-11) and the eleven associated transects (transect numbers 2-12; see Figure 4-1), based on 0.5 kg samples collected from the track slicks (see description, below). Identification, using Maya soil terminology, was based on soil color, texture, and size of grains.

Garden Size, Location, and Distance from X-Hazil Sur

Garden size is important in determining the amount of crops potentially available to wildlife. Location is important in determining the distribution and abundance of gardens around the village where gardeners live. Distance from X-Hazil Sur is important to gardeners in considering the trade-offs between time and effort. For example, gardeners who prefer to plant near the village have shorter travel times, but may have increased competition with other gardeners for favorable sites. On the other hand, gardeners who prefer to plant at greater distances from X-Hazil Sur have longer travel times, but may have reduced competition for sites.

The determination of garden size was based, in part, on information provided by gardeners during the interviews. The basic unit of measurement reported by gardeners was the *mecate*. The *mecate* had a dual function in that it described a linear measurement of 20 m, as well as a square area measuring 20 m on a side (total area = 400 m^2). Some gardeners precisely determined this area using a tape measure, while others estimated this area, for example, by counting paces. A precise measurement of size was important to gardeners because they often contracted out certain phases of the work and used the area worked, instead of an hourly salary, as the basis for determining the payment.

Garden size for the seven selected gardens used to monitor crop phenology (see below) was calculated from measurements of the garden edges and their bearings. Garden edge lengths were measured with a tape measure to within 1 m. Garden edge bearings were measured with a hand-held compass to within 2 degrees. An outline of the garden was made (scale 1:1000), and the area enclosed was measured with a compensating polar planimeter.

Gardeners reported the distance and location of their gardens during the interview by indicating the route taken, making reference to nearby landmarks, and referring to locations of nearby gardens. The accuracy of distance estimates greatly benefitted due to the occurrence of numbered road markers at intervals of 1 km along Mexican Route 307 (see Figure 2-5). Based on this information, aerial photographs, and my familiarity with the area, garden locations were plotted on a base map (scale 1:100,000). Individual garden distances from X-Hazil Sur were calculated to within 0.1 km using the water tank at the western edge of X-Hazil Sur as the reference point. The water tank was used because it is a permanent structure and is indicated on many published maps. Distance measurements for gardens near X-Hazil Sur or those close to roads or other landmarks probably were accurate to within 0.5 km, while distances for the others probably were accurate to within 1 km.

Garden Type and Years of Previous Use

The number of years during which a garden is used is important in determining the rates at which new areas are converted to gardens and gardens are placed in fallow. This will have a direct impact on wildlife and their use of the area. If gardens are planted but a single year, the rate of conversion is much greater than if gardens are used 3-4 y in a row. If an area has a relatively low population density of gardeners and a relatively low forest conversion rate, this rate will not be of much importance because the amount of land used by gardeners is much less than potentially available. However, if the area has a relatively high population density of gardeners and a relatively high forest conversion rate, this rate will be important because overused lands eventually lose their fertility and their ability to grow either crops or forests (Noguez-Galvez, 1991; Nye and Greenland, 1960; Stromgaard, 1986, 1991). This will affect both native plants and wildlife, as well as gardeners.

Crops often were planted and harvested in gardens for two or more years in a row. Based on information provided by the gardener, gardens were aged (number of years of previous use immediately prior to the present growing season) and classified as "new" (not used as a garden the previous year) or "old" (used as a garden the previous year). Gardens categorized as old underwent the entire annual horticultural cycle and were different from managed fallows at other sites (see Alcorn, 1984a, 1984b) where crops continued to be weeded and harvested during subsequent years without additional planting.

Crop Phenology and Mortality

Maya gardeners reported that different species of wildlife use crops at different developmental stages. Accordingly, crop phenology was measured during the 1990 growing season in order to relate specific wildlife use to a particular crop developmental stage.

Crop phenology was monitored in circular plots that were 2 m in diameter (3.1 m^2) at the seven selected gardens. The number of plots per garden was proportional to garden size (about 6-7 plots/ha). Plots were randomly located within gardens and were surveyed about once a month during 7/90-1/91 (month/year), the period of time from planting through harvest. Given that gardeners planted by hand a mixture of four-six seeds per clump in rows at roughly 1-m intervals, a plot size of 3.1 m^2 was selected to assure a sample of three-five seed clumps per plot. Crop density was determined by converting these values to stalks/m^2.

For each plot survey, the following variables were measured for each crop: number of plants (stalks), height of plants (determined by measuring tape to within 5 cm), developmental stage of plants, and evidence of crop predation. The following developmental stages were used (listed in order of maturity): seedling, stalk with flowers, stalk with immature fruits, stalk with mature fruits, and harvested. The harvest dates for the seven selected gardens complemented the information about the annual horticultural cycle obtained through interviews in 1990 because it was not possible to re-interview all 31 gardeners. Crop predation (species of crop predator and type of crop damage) was recorded in order to demonstrate specific use of a crop by wildlife. Although phenology data were collected for all crops, only the results for corn, squash, and kidney beans are presented here.

Several criteria were used in choosing the seven selected gardens: One, the gardener had to agree to the selection. Two, the garden had to be reasonably close to a road or trail in order to facilitate access by project personnel to measure the plots. Three, the vegetation either to the west or to the east of the garden had to be fairly uniform and free of other gardens in order to accommodate a 2000-m-long wildlife census transect (see Chapter 4 for additional information).

Crop mortality was determined during 7/90-10/90 (the growing season in 1990) by counting the number of stalks per plot during the several readings and subtracting the last stalk count from the greatest stalk count for each garden. These values were averaged for the seven gardens. This was necessary as the first reading did not necessarily have the greatest number of stalks per plot. Seeds germinating after 10/90 were ignored in calculating crop mortality.

Wildlife Use of Gardens

Maya gardeners reported that different species of wildlife use gardens at different rates and times of the growing season. Accordingly, wildlife use of gardens was measured during 7/90-1/91 in order to compare seasonal use by month and differences in frequency of garden use among different forest successional stages.

Wildlife use of gardens was measured in two ways: (1) tracks and feeding signs observed in the circular plots used to monitor crop phenology (see description, above) and (2) track slicks along gardens or along transects in forests adjacent to gardens. The track slicks were 1 m by 20 m in size and were specially located at sites where wild animals were likely to pass. Track slicks were prepared by spading the soil, removing all rocks and roots, and raking the soil to produce a smooth surface. The slicks were surveyed about once a month during 7/90-1/91, usually on the same date as crop phenology was monitored in the corresponding garden. For each track set observed, species and comments about the soil humidity of the slick as it related to clarity and duration of track sets were recorded. Track slicks were maintained, as necessary, by supplemental raking and weeding, but the area around the track slick was not disturbed.

Track slicks were surveyed by two local Maya men who also were experienced hunters. Tracks were identified on the basis of their size and shape, as well as associated hairs, feathers, feces, game trails, or feeding sign. When unknown tracks were encountered, the track readers consulted with other knowledgeable hunters at X-Hazil Sur to determine the species that made the tracks.

Track slicks were located along the edges of the seven selected gardens (one track slick per garden) and were used to measure wildlife use of gardens. Seven additional track slicks were located in the adjacent forest along the transects extending from the seven selected gardens (one transect per garden and one track slick per transect). The purpose of these track slicks was to determine if there were any differences between wildlife use of gardens and the adjacent forest. Transects were about 2000 m in length and were used during wildlife censuses to determine wildlife densities (see Chapter 4). A single track slick was located on each transect at about 40-220 m from the edge of the garden for comparative purposes. Track slicks along transects were prepared and read in the same manner as the garden track slicks.

Four additional track slicks were located in forests on four transects (transects number 2, 3, 4, and 12) that did not extend from gardens. These track slicks were prepared and read as described above, and were used as a control to compare wildlife use of gardens in Early Secondary Forest versus Late Secondary Forest with Gardens.

Wildlife species were identified on the basis of descriptions provided by gardeners, consultation with reference books (Leopold, 1977; Peterson and Chalif, 1973), and by comparison with wildlife shot by hunters (see Chapter 3 for additional information). Voucher specimens were identified by Mexican biologists and deposited at the Museo de Vertebrados, Centro de Investigaciones de Quintana Roo, Chetumal, Quintana Roo, Mexico.

Statistical Methods

The results presented in this chapter were based on three data sets: One, during 1989 and 1990, gardeners were interviewed to determine number of gardeners, number of gardens, annual horticultural cycle, years of previous use, garden size, garden distance from X-Hazil Sur, number of crops planted, number of crops per garden, and reported crop predation. Two, during 1990, seven gardens were selected for an intensive study of crop phenology, density and mortality of crops, and actual crop predation. Three, during 1990, track slicks at 18 sites were used to compare wildlife use of gardens versus use of adjacent forest, wildlife use of the three vegetation types, and monthly variation in wildlife use of the three vegetation types.

Parametric and nonparametric tests were used to analyze garden and wildlife data. For the chi-square comparison (χ^2) of garden crops between years, three crops (*chaya*, lentils, and other) were combined to obtain an expected cell frequency $\geq$ 5. The nonparametric Kruskal-Wallis test (χ^2 approximation) was used for variables where the observations likely were not independent or normally distributed. For example, several gardeners reported that they always planted their fields near those of other family members. Several gardeners also reported that they always planted a single crop of corn in large gardens and mixed crops in smaller gardens. The results are presented as χ^2 = chi-square; χ^2 approximation = chi-square approximation; $\bar{x}$ = mean; SE = standard error; n = sample size; d.f. = degrees of freedom; and P = significance level. All statistical analyses were conducted using SAS (SAS Institute Inc., 1988).

Results

Gardeners

Number of gardeners. Data for this part of the study were obtained during 6/89-1/91 (month/year). In 1989, 180 interviews of widows and adult men were conducted during 6/29-8/22 (month/date) to determine the extent to which X-Hazil Sur residents planted gardens. A total of 123 residents (2 women and 121 men, representing about 60% of the total number of households at X-Hazil Sur) reported having planted a total of 150 gardens in 1989; 14 residents (7% households) reported having cleared a total of 17 gardens, but had not planted them by the date when the interview was conducted; and 43 residents (20% households) reported that they had not cleared or planted a garden that year. In 1990, 31 randomly selected gardeners that had planted in 1989 were interviewed during 11/22-11/24 and reported having planted a total of 40 gardens, while another 5 residents who also planted in 1989 reported that they had not planted in 1990. Thus, about 80-85% of the *ejidatarios* planted gardens.

Number of gardens per garden group. Garden groups frequently planted more than one garden per group. In 1989, each group planted an average of 1.2 gardens ($\underline{SE}$ = 0.05, $\underline{n}$ = 123 garden groups). One garden group planted 4 gardens, 3 groups planted 3 gardens each, 18 groups planted 2 gardens each, and 101 groups planted 1 garden each. In 1990, each garden group planted an average of 1.3 gardens ($\underline{SE}$ = 0.11, $\underline{n}$ = 31 garden groups). Two groups planted 3 gardens each, 5 groups planted 2 gardens each, and 24 groups planted 1 garden each. The number of gardens planted per garden group was not significantly different between years (χ^2 approximation = 0.4094, $\underline{d.f.}$ = 1, $\underline{P}$ = 0.5223).

Gardens

Annual horticultural cycle. The annual horticultural cycle consisted of six main periods: initial site clearing (felling trees and brush), burning, planting, weeding, doubling over of corn stalks, and harvesting (Figure 6-1). These activities frequently overlapped in time and collectively occurred throughout the year.

Initial site clearing occurred primarily during January-April and consisted of using an axe or machete to cut down brush and small trees (Figure 6-1). Large trees usually were not cut down, while medium-sized trees usually were cut at waist height (A. Tuz Novelo, pers. comm.). The brush and small trees were left to dry at the site. Clearing occurred over several weeks. Some gardeners cleared sites as late as April-June.

Gardens individually were burned on a single day--usually in an afternoon--and collectively were burned during the month of April (Figure 6-1). Gardeners carefully timed the blaze to maximize burn completeness and ash production, thus facilitating planting and increasing soil fertility. If the burn took place too early in the season, gardeners indicated, the brush and trees would resprout and the ash would blow away with the wind. If the burn took place after the rains had begun, the blaze likely would be incomplete and little ash would be available to fertilize the garden. Gardeners rarely attempted to reburn areas that did not burn initially (M. Cab Cohuo, pers. comm.). The quality of a burn was extremely important as an incomplete or improperly timed burn would reduce crop yields and make planting more difficult.

There were two planting periods: an intense period during May-July and another period during the rest of the year when seeds were sown at irregular intervals (Figure 6-1). During the first period, squash (*Cucurbita pepo*), sweet potato (*Ipomoea batatas*), bean (*Phaseolus* spp.), lentil (*Lens esculenta*), yam (*Dioscorea* sp.), and corn (*Zea mays*) were the main crops planted. During the second period, *jícama* (*Pachyrrhizus erosus*) was the main crop planted, while some *macal* and *ibes* (*Phaseolus lunatus*) seeds also were planted at this time. The main planting usually took about 1-2 weeks per garden and began after heavy rains had thoroughly moistened the soil (F. Balam Can, pers. comm.). Usually a mixture of seeds was sown throughout the garden. Often, however, seeds such as *jícama*, lentils, and chili (*Capsicum annuum*) were specifically planted in a small part of the garden that had better soil and was better tended than the rest of the site.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
GARDEN ACTIVITY:												
Clear	---	---	---	---								
Burn				---								
Plant					---	---	---					
Weed							---	---	---			
Double corn									---	---		
Harvest	---										---	---
WEATHER:												
Temperature					Max							Min
Rainfall						---	---	---	---	---	---	---

Figure 6-1. Annual horticultural cycle at Ejido X-Hazil y Anexos during 1989-1990 (Max = month with highest mean temperature and Min = month with lowest mean temperature).

Weeding took place during July-September (Figure 6-1). Most gardeners weeded once or twice, as needed and as time permitted (2-4 weeks per garden per weeding; R. Cab Cohuo, pers. comm.). Gardeners either pulled weeds by hand or cut them with a machete or hooked knife. Pesticides and herbicides generally were not used in gardens but were used on plots in the fruit corridor east of X-Hazil Sur, along Highway 307 (E. Che Canul, pers. comm.).

Corn plants were doubled over during September-October in order to facilitate drying and to protect the cobs from crop predators such as parrots (Family Psittacidae) and coatis (*Nasua nasua*; see below; Figure 6-1). Other garden crops were not doubled over.

Corn plants were harvested during November-January (Figure 6-1). Other crops were harvested as they became ripe or were needed by the gardener. For example, yams, squash, and sweet potatoes did not spoil quickly and could be harvested up to 6-12 months after planting (M. Cab Ake, pers. comm.).

The 1989 annual horticultural cycle, according to local residents, was highly unusual in that rains were intermittent, late to begin, and less substantial than normal (see Figure 2-4). As a result, many residents delayed planting, replanted, or abandoned their gardens. Some garden crops dried up, while weeds grew faster than did crops in other gardens. Although harvests were not measured, gardeners reported that only about 10-20% of the gardens produced an average crop in 1989, while the other gardens produced below-average yields.

Due to the irregular nature of the rains in 1989, data for the timing of horticultural activities that year were limited to the date of first planting. The median first date of planting was 5/12-5/13 (n = 150 gardens). The earliest reported planting was on 4/1, while the latest first planting was on 8/7. At least seven gardens were completely replanted once and two were completely replanted twice. Other gardens were partially replanted as large numbers of seedlings died due to the irregular and inadequate rains.

The 1990 annual horticultural cycle, according to residents, was about normal and most gardeners achieved an average harvest. The median date to begin initial site clearing was 2/15 (range = 9/15/89-6/1/90, n = 40 gardens; month/date/year). The median date to burn the garden site was 74 days later, on 4/30 (range = 3/1-6/30, n = 40 gardens). The median date to plant was 32 days later, on 6/1-6/2 (range = 4/30-7/15, n = 40 gardens). Weeding and doubling took place during 8/90-10/90. The corn harvest began about 10/30 and was complete by about 12/8 (n = 7 gardens).

Garden type and years of previous use. Most gardens were planted on sites that had not been used as gardens the previous year. In 1989, the average number of years that a site had been used previously as a garden was 0.1 (SE = 0.05, n = 150 gardens, range = 0-5 y). About 91% of the 150 gardens were on sites categorized as new, while 9% were on sites categorized as old. In 1990, the average number of years that a site had been used previously as a garden was 0.0 (SE = 0.02, n = 40 gardens, range = 0-1 y). About 98% of the 40 gardens were on sites categorized as new, while 2% were on sites categorized as old. The number of years of previous use for gardens was not significantly different between years (χ^2 approximation = 1.7769, d.f. = 1, P = 0.1825).

One gardener indicated that he had cleared a field in Late Secondary Forest in 1989. All other gardeners reported that they had cleared fields in Early Secondary Forest. The importance of this is that *ejido* and state forestry rules forbid clearing gardens in Late Secondary Forest (D. Ake Ayala, pers. comm.).

Size. Gardens ranged in size from relatively small (minimum = 0.3 ha) to quite large (maximum = 18.0 ha), but 70% were 1.0-2.9 ha in extent in 1989, while 62% were that size in 1990 (Figure 6-2). In 1989, the average garden size was 2.1 ha (SE = 0.11, n = 150 gardens, range = 0.3-8.0 ha, total area = 310.84 ha). In 1990, the average garden size was 2.7 ha (SE = 0.45, n = 40 gardens, range = 0.5-18.0 ha). Garden size was not significantly different between years (χ^2 approximation = 1.4455, d.f. = 1, P = 0.2293). Based on the 1989 information for X-Hazil Sur, the total area for the *ejido* in gardens would be about 545 ha (ca. 1% of the total area available; about 346 households times 0.75 gardens per household times 2.1 ha per garden).

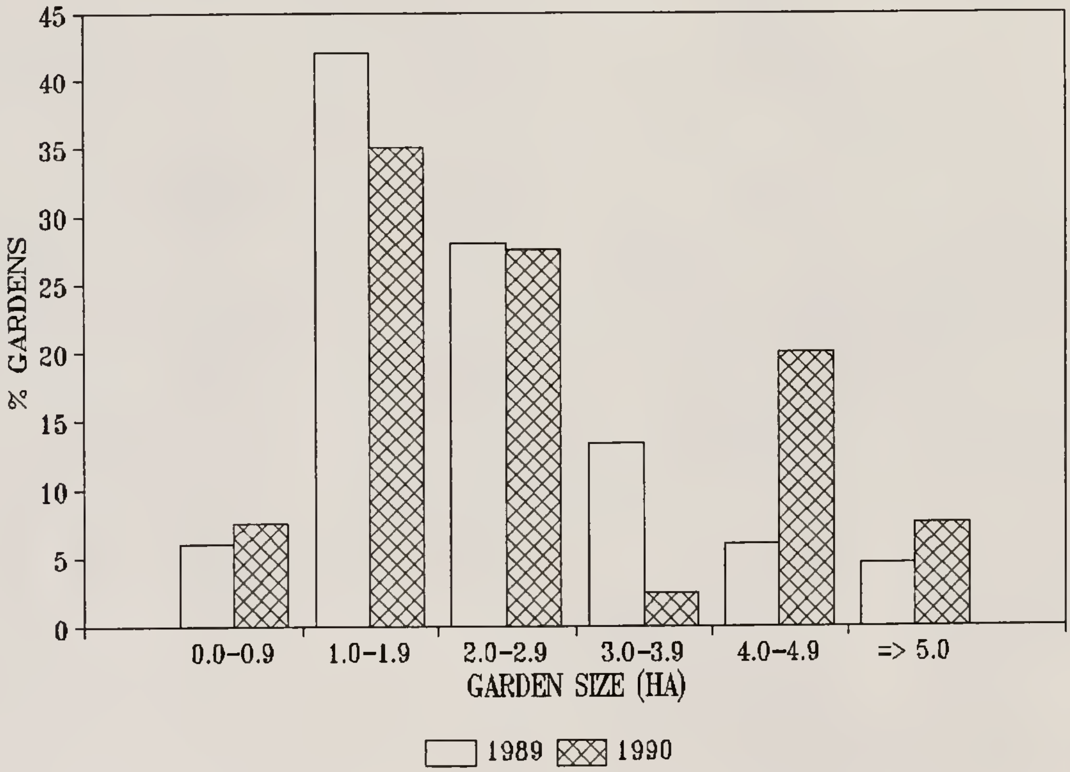

Figure 6-2. Distribution of gardens by size during 1989 (n = 150 gardens, average size = 2.1 ha) and 1990 (n = 40 gardens, average size = 2.7 ha).

Soil type of gardens. Soil type was determined for the seven selected gardens and the 11 associated transects. Two types were determined (Mr. P. Macario Mendoza, in litt.); *K'ankab* and *Yaax'hom*. *K'ankab* soil, the most common, was identified for six of the seven selected gardens (numbers 5, 6, 7, 8, 9, and 11). This soil is red due to the concentration of iron oxides and the leaching out of black organic matter. *K'ankab* soil is relatively poor in phosphorus and nitrogen and is subject to laterization when bared to the sun. This soil is slightly acidic (pH 6.5-7.5) and has 10-15% organic matter and 26% clay. *Yaax'hom* soil was identified only for garden number 10 (see Figure 4-1 for location of gardens and transects). This soil is black. Yaax'hom soil also is slightly acidic (pH 6.5-7.5) and has 5-20% organic matter and 62% clay (soil description from Snook, 1993).

Distance from X-Hazil Sur. Gardens were located at distances that ranged from relatively close to X-Hazil Sur to quite far away (minimum distance = 0.6 km, maximum distance = 16.6 km), but about 50% were at 1.0-2.9 km (Figure 6-3). In 1989, the average garden distance from X-Hazil Sur was 4.0 km (SE = 0.29, n = 150 gardens, range = 0.7-16.6 km). In 1990, the average garden distance was 3.8 km (SE = 0.50, n = 40 gardens, range = 0.6-15.9 km). Garden distance was not significantly different between years (χ^2 approximation = 0.1730, d.f. = 1, P = 0.6774).

Several gardeners indicated that competition with other gardeners had forced them to sow gardens at alternate sites on the study area as the intended site already had been taken. One common tactic used by gardeners to obtain additional land was to plant a garden adjacent to that of another gardener. Usually the adjacent gardener abandoned the vicinity after the harvest season. Another tactic was to clear a narrow strip of land around a potential garden site, in effect laying claim to the area, but not actually clearing or planting the site until a few years later, when hopefully any neighboring gardeners had left the area.

Crops planted. Gardeners reported planting a wide variety of crops in their gardens. In 1989, gardeners reported planting 16 types of crops, while in 1990, 13 were reported (Figure 6-4).

Three crops were more frequently planted than other crops: corn (99% of gardens in 1989 [n = 150 gardens] and 100% in 1990 [n = 40 gardens]), squash (84% and 63%), and kidney beans (75%

Figure 6-3. Distribution of gardens by distance from *X-Hazil Sur* during 1989 (n = 150 gardens, average distance = 4.0 km) and 1990 (n = 40 gardens, average distance = 3.8 km).

and 48%; Figure 6-4). The frequency with which crops were planted in gardens was not significantly different between years (χ^2 = 11.510, d.f. = 10, P = 0.319).

Gardens typically contained several crops. In 1989, the average number of crops planted per garden was 5.9 (SE = 0.25, n = 150 gardens, range = 1-12 crops per garden; Figure 6-5). In 1990, the average number was 3.9 (SE = 0.47, n = 40 gardens, range = 1-11 crops per garden). The number of crops planted per garden was significantly different between years (χ^2 approximation = 13.773, d.f. = 1, P = 0.0002).

Crop phenology. Although planted at the same time, seeds in a particular garden may not germinate at the same time or develop at the same rate. This may affect wildlife use of gardens if wild animals select for or against certain plant species or plant parts (e.g., corn cob or sweet potato tuber).

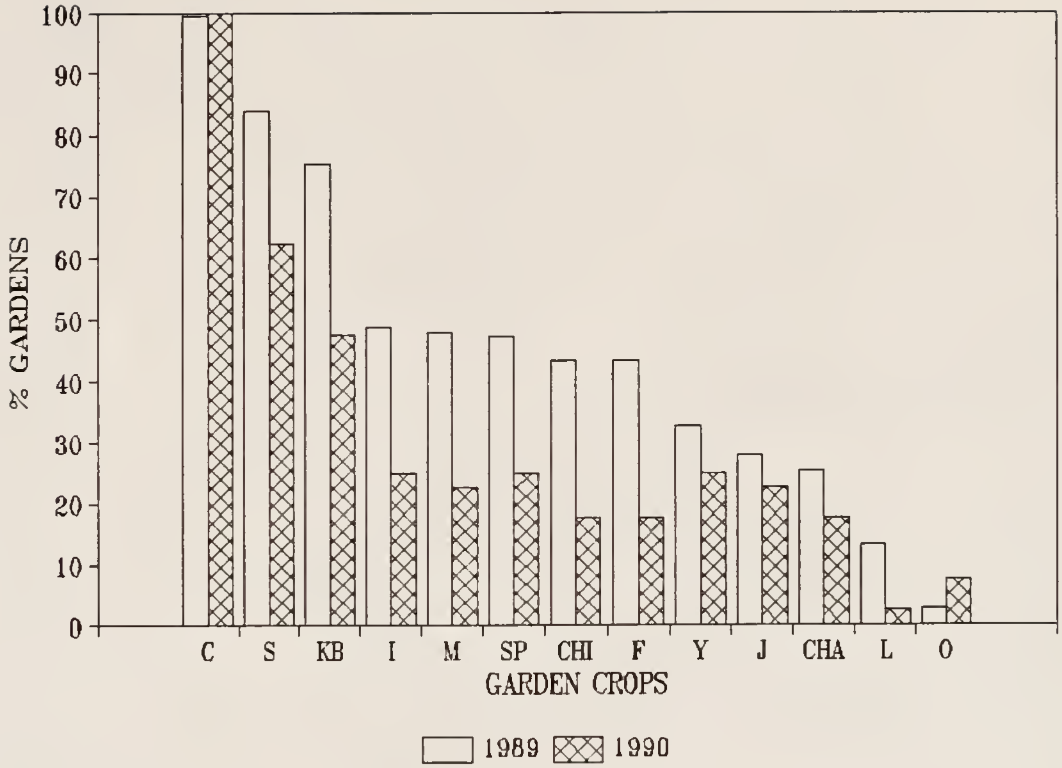

Figure 6-4. Frequency with which crops were planted in gardens during 1989 and 1990 (C = corn, S = squash, KB = kidney beans, I = ibes, M = yam, SP = sweet potato, CHI = chile, F = fruits, Y = yucca, J = jícama, CHA = chaya, L = lentils, and O = other).

Crop phenology was studied intensively on the seven selected gardens in 1990. Six of the seven selected gardens were planted during 6/13-6/28, while one was planted about 7/25. The seven selected gardens were surveyed eight times each during 7/90-1/91. The number of reported observations per gardens, however, was less than the number of garden surveys as some gardens were planted later or harvested earlier than others. Gardeners reported that the key factor in deciding when to plant was sufficient rainfall. In 1990, relatively heavy rainfall occurred at the beginning of the planting season on 4/3 (11.2 mm), 4/12 (13.5 mm), 4/27 (40.0 mm), 6/7 (16.0 mm), and 6/8 (20.5 mm; see Appendix A). Many gardens were planted soon after each of these dates.

Corn, the most abundant crop according to the density of stalks (see below), was present in the gardens for about six months in 1990. During 7/90-8/90, corn plants primarily were at the seedling stage (Figure 6-6). In 9/90, about 37% of the plants were seedlings, 29% had flowers, and 34% had

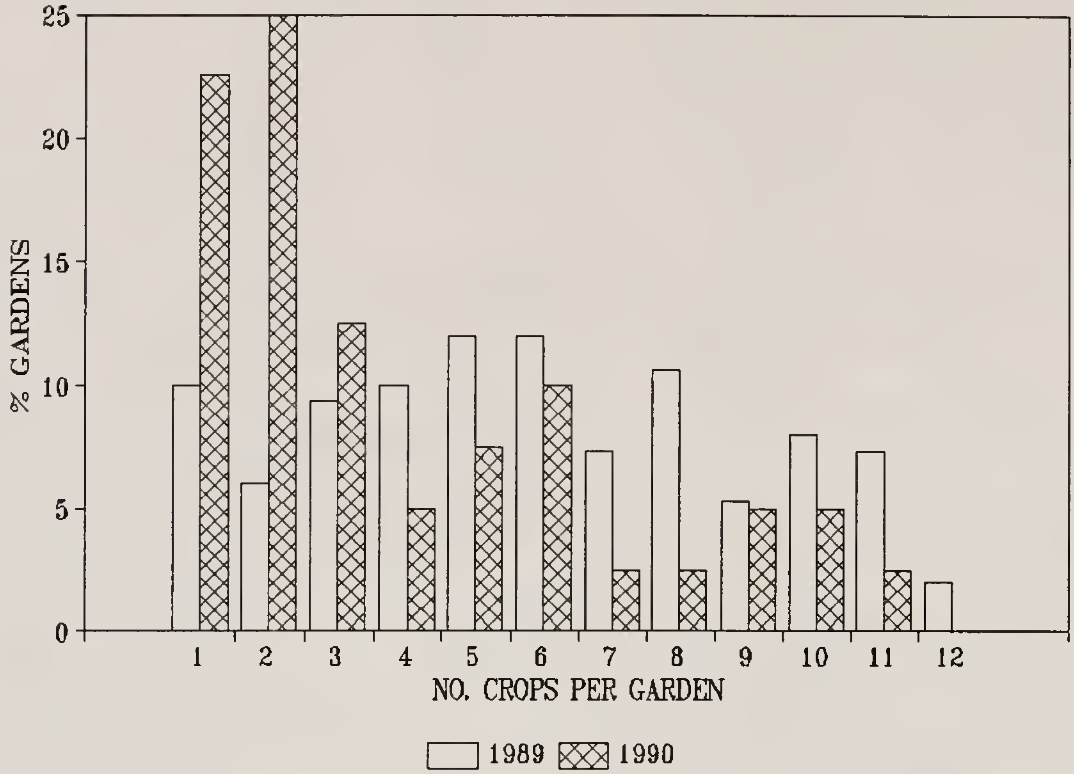

Figure 6-5. Number of crops per garden during 1989 (n = 150 gardens, average = 5.9 crops per garden) and 1990 (n = 40 gardens, average = 3.9 crops per garden).

immature fruits (cobs). During 10/90, about 25% of the corn plants had immature cobs, 50% had mature cobs, and 23% had been harvested. In 11/90, 68% of the plants had mature cobs and 32% had been harvested. By the end of 12/90, all of the corn had been harvested.

Kidney beans, the second most abundant crop, were present in the gardens for about six months in 1990. During 7/90-10/90, kidney bean plants were at the seedling stage (Figure 6-7). In 11/90, about 52% of the plants had flowers, while 39% had been harvested. During 12/90, about 26% of the kidney bean plants were seedlings, about 24% had flowers, and 50% had been harvested. By 1/91, all of the kidney beans had been harvested.

Squash, the third most abundant crop, was present in the gardens for about four months in 1990. During 7/90-9/90, squash plants primarily were at the seedling stage, but 4-6% of the plants had mature fruits during 8/90-9/90 (Figure 6-8). In 11/90, 100% of the plants were harvested, but in 12/90

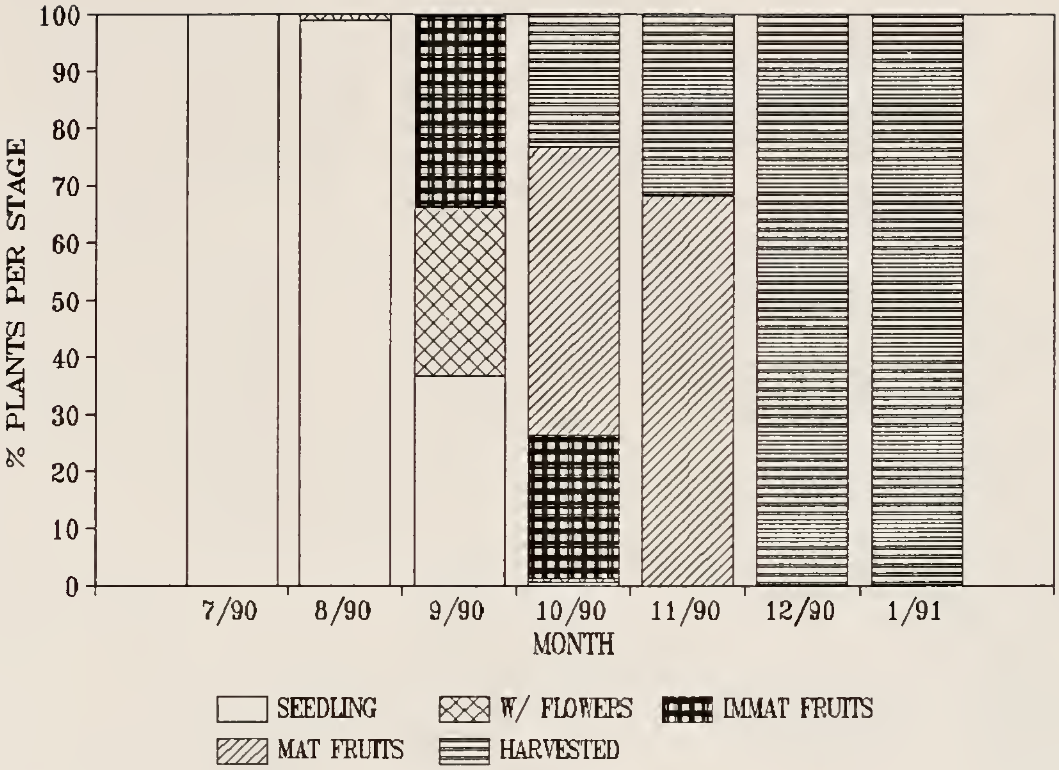

Figure 6-6. Monthly phenology of corn plants in seven selected gardens during 1990 (n = 7 gardens). Plants were categorized as seedlings, with flowers, with immature fruits, with mature fruits, and harvested.

additional squash germinated and 17% had mature fruits seedlings. By 1/91 all remaining squash were harvested.

Density and mortality of crops. The density of seedlings varied greatly among the seven selected gardens. Garden number 6 had the least number of stalks at 45.9 stalks/m^2 (n = 6 surveys), while garden number 10 had the greatest number at 179.0 stalks/m^2 (n = 5 surveys; Table 6-1). The average plot had 92.5 stalks/m^2 and was composed primarily of corn (87% of stalks), kidney beans (5%), and squash (3%).

Not all of the crop seeds that germinated in the seven selected gardens developed and produced mature fruits that could be harvested. Among the three major crops, squash seedlings experienced the greatest mortality with an average loss of 82% (SE = 4.26, n = 6 gardens), while kidney beans experienced an average loss of 62% (SE = 7.02, n = 7 gardens), and corn experienced an average

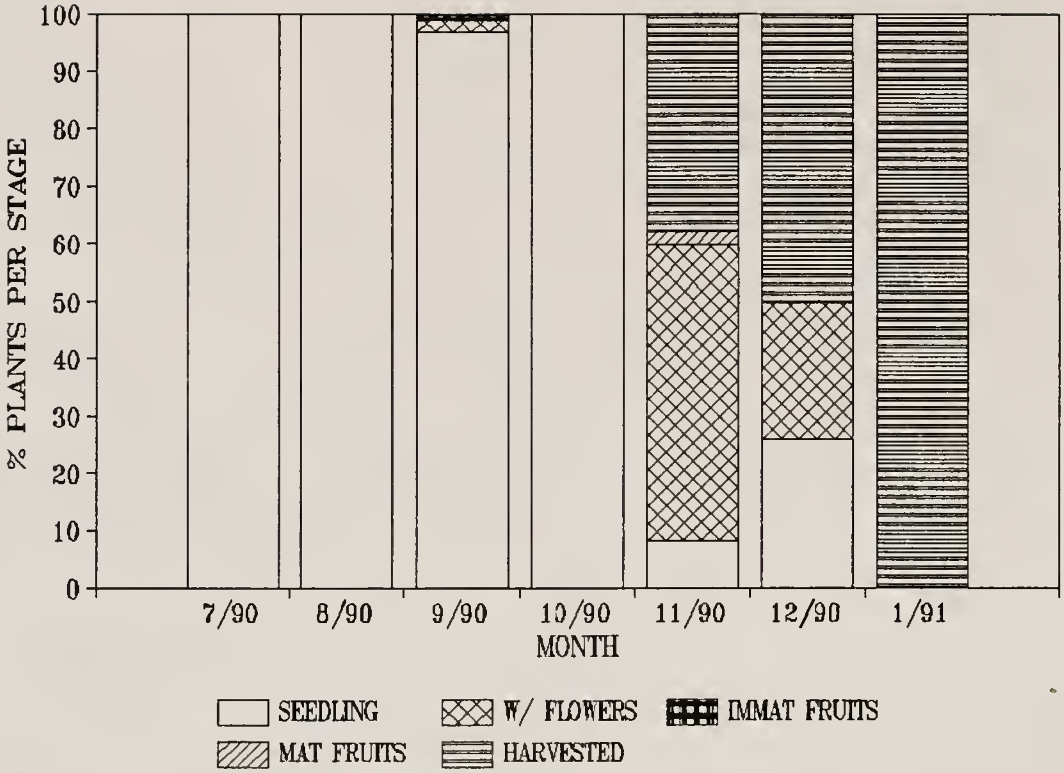

Figure 6-7. Monthly phenology of kidney beans at seven selected gardens during 1990 (n = 7). See Figure 6-6 for key to abbreviations.

loss of 21% (SE = 4.42, n = 7 gardens).

Wildlife Use of Gardens and Adjacent Forest

Crop predation. Wild animals can use gardens as sites to obtain food or locations where social interactions may take place. This use may be dependent upon either the wildlife species or the developmental stage of the crops in the gardens or both.

Fourteen taxa of wild animals were identified by gardeners as the main crop predators. In 1989, wildlife identified as "birds" were the main crop predator at 50% of the gardens (n = 150 gardens; Figure 6-9). Gardeners generally did not identify a specific avian taxon as the main crop predator, but instead usually mentioned a combination of parrots (Psittacidae), jays (Corvidae),

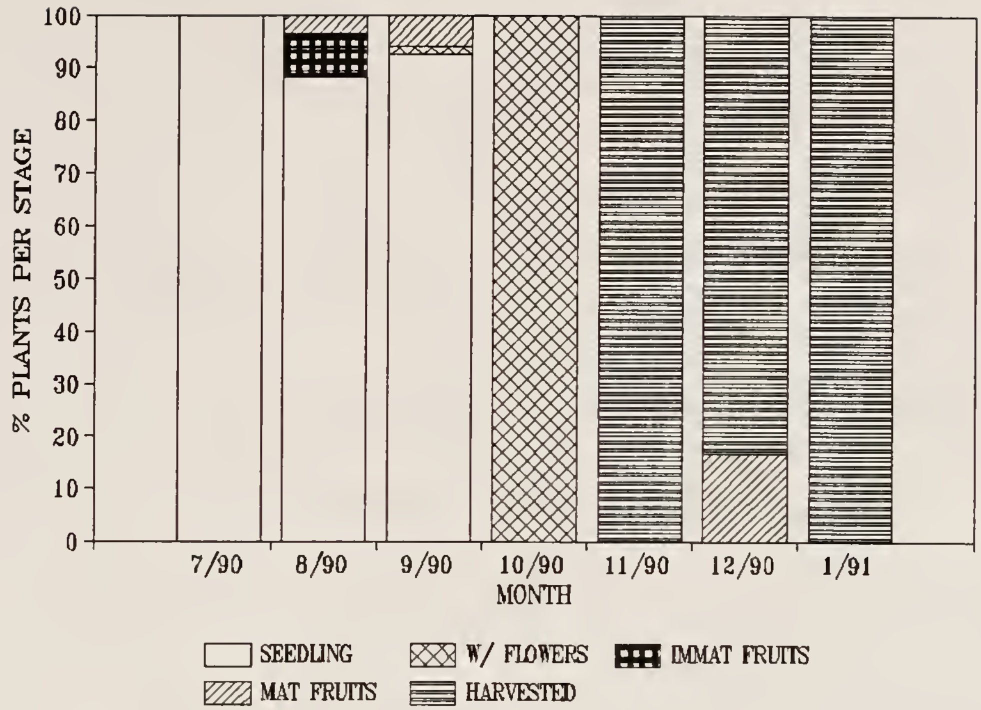

Figure 6-8. Monthly phenology of squash as seven selected gardens during 1990 (n = 7 gardens). See Figure 6-6 for key to abbreviations.

blackbirds (Icteridae), and pigeons and doves (Columbidae; see Appendix Z for a list of common and scientific names of crop predators). The coati was the main mammalian crop predator at 13% of the gardens in 1989, while crop predation was not a problem at 11% of the gardens. In 1990, the coati was the main crop predator (30% of gardens, n = 40 gardens), but the collared peccary (*Tayassu tajacu*; 23%), birds (20%), and taxa summarized as "other" (15%) also were reported by gardeners.

Actual crop predation in crop phenology study plots was observed on two occasions. On 10/30/90, paca (*Agouti paca*) tracks and feeding sign on a corn plant were observed in garden eight, and on 1/18/91, agouti (*Dasyprocta punctata*) tracks and feeding sign on a *camote* plant (tuber) were observed in garden seven. White-tailed deer (*Odocoileus virginianus*) tracks were observed on 9/10/90 in garden eight, but no crop predation was noted. Other examples of crop predation in gardens were noted, but were not included here as they did not specifically occur on the study plots.

Table 6-1. Density of crops (mean number of stalks/m^2) planted in the seven selected gardens in 1990. For crop density, the plots were surveyed during 7/90-11/90, beginning before planting and ending when the corn harvest began in the garden. Additional surveys were conducted through 1/91 to monitor crop phenology.

	Garden number and soil type (Mean number of stalks/m^2)								
Crop[a]	5[b]	6[b]	7[b]	8[b]	9[b]	10[c]	11[b]	Mean number of stalks (n = 7 gardens)	SE
Corn	89.8	36.8	43.1	108.4	57.8	156.5	74.0	80.9	15.82
Kidney bean	7.6	1.7	2.1	9.2	0.0	6.3	6.5	4.8	1.31
Squash	0.0	0.4	1.4	5.8	2.4	6.5	3.6	2.9	0.96
Other	0.0	7.0[d]	4.1[e]	0.6[f]	0.0	2.5[g]	0.0	2.0	1.02
Sweet potato	0.0	0.0	5.9	0.7	0.0	1.7	3.1	1.6	0.83
Lentil	0.0	0.0	0.0	0.0	0.0	5.4	0.0	0.8	0.77
Yam	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.4	0.40
Jícama	0.0	0.0	1.0	0.0	0.0	0.0	1.3	0.3	0.21
Mean total	97.3	45.9	51.7	124.8	60.2	179.0	88.4	92.5	17.90
No. surveys	5	6	5	6	6	5	5	5.4	
Garden size (ha)	1.2	0.6	0.6	1.2	0.6	2.5	1.2	1.1	
No. plots	8	5	5	8	5	12	8	7.3	

[a] Includes only crops planted in seven selected gardens.
[b] *K'ankab* soil type.
[c] *Yaax'hom* soil type.
[d] *Zacate.*
[e] Watermelon & sugar cane.
[f] Banana.
[g] Lec (*Lagenaria siceraria*).

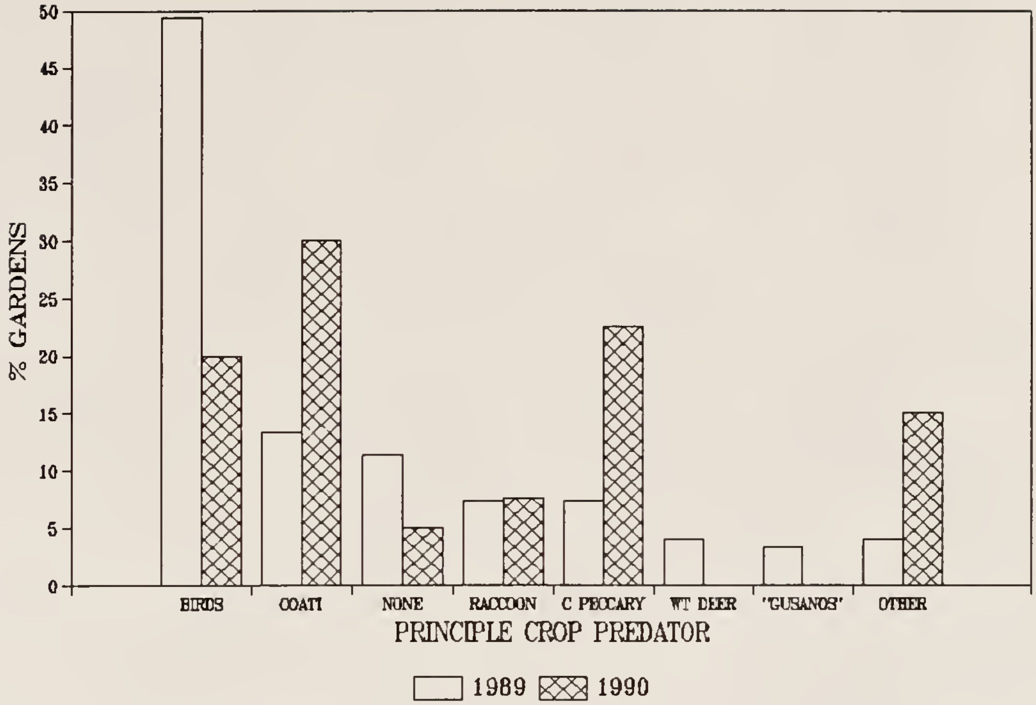

Figure 6-9. Frequency with which wild animals were identified by gardeners as the main crop predators during 1989 and 1990 (none = no crop predators, c peccary = collared peccary, wt deer = white-tailed deer, *gusanos* = various taxa of Gastropods).

Wildlife tracks. Wildlife track surveys were used as a tool to complement measurements of crop predation because wild animals could either have entered a garden in order to consume a cultivated plant or to conduct some other activity. Track surveys also complemented the wildlife censuses (see Chapter 4) in determining which species occurred in an area and the frequency with which specific areas of habitat were used by wildlife. A survey of track slicks suggested that there were differences in wildlife use patterns by month, vegetation type, and between gardens and adjacent forest.

A total of 96 tracks sets were recorded from 18 track slicks during 7/90-1/91 (Table 6-2). These tracks were made by seven species of game mammals, two species of game birds, and eight species of nongame mammals (see Chapter 3 for a discussion of game and nongame species). Dogs, as

Table 6-2. Frequency of occurrence of wildlife track sets in 18 track slicks (1 m by 20 m) along gardens and transects in adjacent forest during 1990.

	Number of track sets by vegetation types and track slick location							
	Late Secondary Forest without Gardens	Late Secondary Forest with Gardens			Early Secondary Forest			
Species[a]	Tran.[b]	Gar.[c]	Tran.	Total	Gar.	Tran.	Total	Grand total
a) Mammals								
Opossum		1		1				1
Armadillo	2	7	8	15	7	8	15	32
Pocket gopher*						1	1	1
Agouti*	3	13		13	2	3	5	21
Paca*	2	2		2	3		3	7
Grey fox		2		2	3		3	5
Coati*					1		1	1
Tayra	1							1
Skunk			1	1	2		2	3
Puma/Cougar						1	1	1
Unknown felid					1		1	1
Collared peccary*						2	2	2
White-tailed deer*	3	2	1	3		1	1	7
Brocket deer*	4							4
Unknown mammal	1	1		1	2	1	3	5
Total mammals	16	28	10	38	21	17	38	92
b) Birds								
Plain chachalaca*		1	1	2		1	1	3
Great curassow*						1	1	1
Total birds		1	1	2		2	2	4
Grand total	16	29	11	40	21	19	40	96
Number taxa	7	8	4	9	8	9	14	17
Number readings[d]	48			38			49	135

[a] * = Game species.
[b] Tran. = Track slick along transect.
[c] Gar. = Track slick along garden.
[d] Number of times the track slicks were surveyed for animal tracks.

well as humans left tracks on the slicks, but their tracks were not counted. Armadillo (*Dasypus novemcinctus*; 33% of total) and agouti (22%) tracks were most frequently observed among the 17 taxa reported.

The track sets observed in garden and transect track slicks represented wildlife use over a relatively short period of time. Although not specifically measured during this study, the duration of wildlife tracks was estimated by repeated observations of tracks during other phases of the project. Tracks made by mammals in relatively dry soil usually lasted about 1-3 days, while those made in relatively moist soil usually lasted about 5-7 days. Bird tracks usually remained visible for only 1-2 days. Wind, rain, soil depth, soil moisture content, extent of canopy coverage, and amount of ground litter, however, affected the duration of all track sets.

<u>Use of gardens versus adjacent forest</u>. Although small sample sizes precluded statistical analyses, at seven sites (three sites in Late Secondary Forest with Gardens and four sites in Early Secondary Forest) it was possible to compare wildlife use of gardens and the adjacent forest simultaneously in a descriptive manner. For these two vegetation types, the number of track sets observed in garden track slicks was greater than the number of track sets observed in transect track slicks (29 track sets versus 11 track sets in 38 readings for Late Secondary Forest with Gardens and 21 track sets versus 19 track sets in 49 readings for Early Secondary Forest; Table 6-2).

Use patterns of garden and transect track slicks by wild animals were not tested statistically, but differed numerically for the two most frequently reported species (Table 6-2). For the armadillo, the number of track sets in garden track slicks was about equal to the number in transect track slicks in both Late Secondary Forest with Gardens (7 track sets versus 8, respectively, for 38 readings) and Early Secondary Forest (7 track sets versus 8, respectively, for 49 readings). For the agouti, however, the number of track sets in garden track slicks was about equal to the number in transect track slicks in Early Secondary Forest (2 track sets versus 3, respectively, for 49 readings), but in Late Secondary Forest with Gardens, 13 track sets were recorded for garden track slicks while 0 track sets were recorded for transect track slicks (38 readings).

Variation in wildlife use by vegetation type. Based on a descriptive analysis of the data, there were differences in the number and kinds of track sets by vegetation type. Among the three vegetation types, track slicks in Late Secondary Forest without Gardens had fewer taxa (7 taxa) and fewer track sets (16 track sets per 48 readings), while track slicks in Early Secondary Forest had the greatest number of taxa (14 taxa per 49 readings, including 7 game taxa; Table 6-2). The number of track sets in Late Secondary Forest with Gardens and Early Secondary Forest were about equal at 40 per 38 readings and 40 per 49 readings, respectively.

Use patterns of track slicks in Late Secondary Forest without Gardens, Late Secondary Forest with Gardens, and Early Secondary Forest differed numerically for the two most abundant species (Table 6-2). For the armadillo, the number of track sets in Late Secondary Forest with Gardens and Early Secondary Forest track slicks was about equal at 15 track sets per 38 readings and 15 track sets per 49 readings, respectively, while relatively few track sets were recorded for Late Secondary Forest without Gardens (2 track sets per 48 readings). For the agouti, however, the number of track sets in Late Secondary Forest with Gardens was greatest at 13 track sets per 38 readings, while relatively few track sets were recorded for Late Secondary Forest without Gardens (3 track sets per 48 readings) and Early Secondary Forest (5 track sets per 49 readings).

Monthly variations in wildlife use of gardens and adjacent forest. Wildlife species exhibited monthly differences in the frequency with which they used gardens and adjacent forests. Overall, 93% of the track sets were observed in the wet season during 7/90-10/90 (Figure 6-10; data from Table 6-2). For Late Secondary Forest with Gardens, the peak of use was in the wet season during 7/90-9/90 (75% of track sets; n = 40 track sets during 38 readings), while peak usage in the other two vegetation types was noted over shorter periods of time (81% of the track sets for Late Secondary Forest without Gardens [n = 16 track sets during 48 readings] were observed during 8/90-9/90 and 68% of the track sets for Early Secondary Forest [n = 40 track sets during 49 readings] were observed in the wet season during 7/90-8/90). Only five track sets were observed during 11/90-1/91 as the wet season ended and the dry season began.

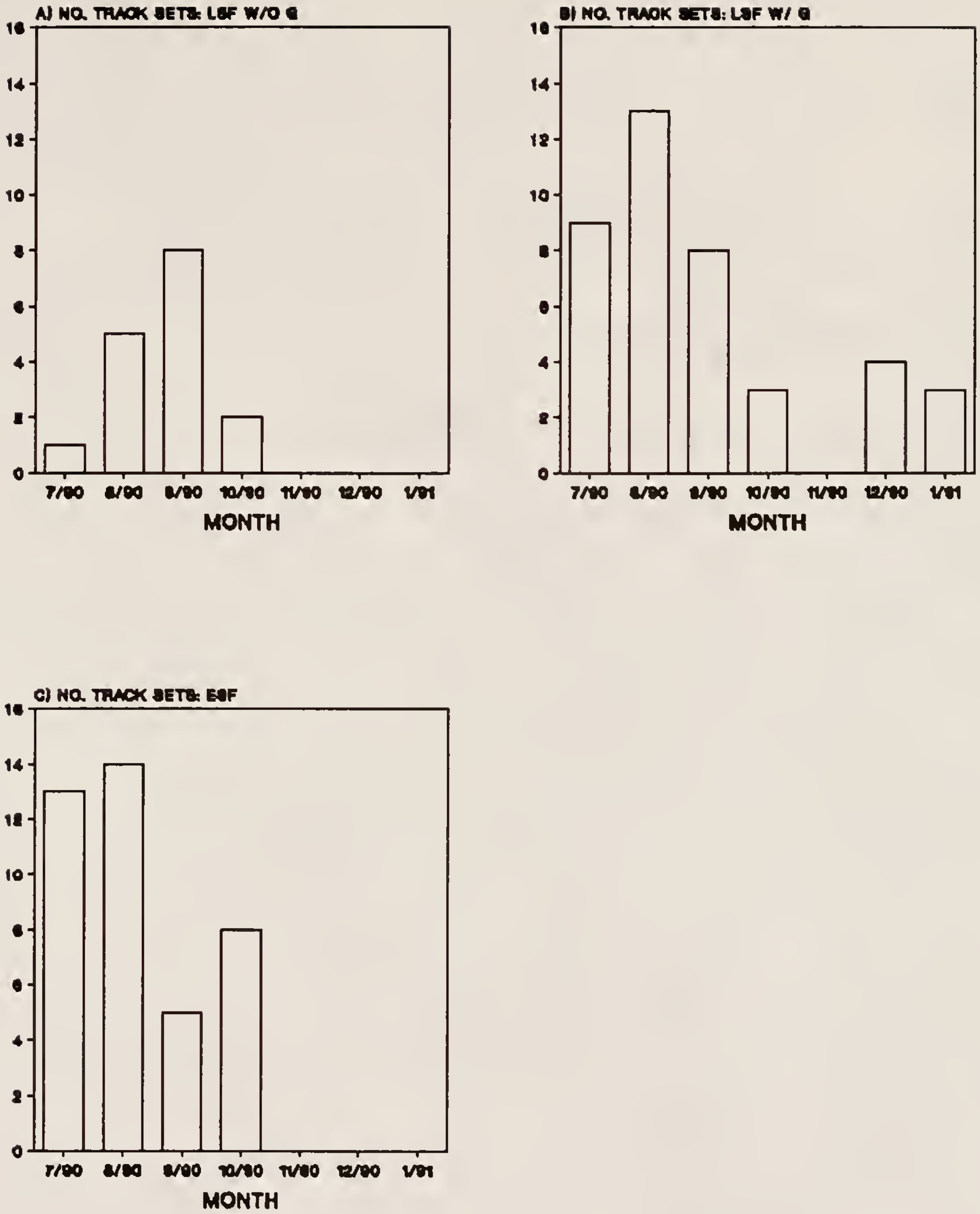

Figure 6-10. Monthly frequency of wildlife track sets in a) Late Secondary Forest without Gardens (LSF W/O G; 16 track sets during 48 readings), b) Late Secondary Forest with Gardens (LSF W/ G; 40 track sets during 38 readings), and c) Early Secondary Forest (ESF; 40 track sets during 49 readings).

Discussion

From the perspective of this study, gardens are important for two reasons: One, gardens provide a source of food to game animals. In Chapter 5, the frequency and abundance of garden crops in the stomach contents of game animals were quantified. Those results will be discussed below with respect to the information presented in this chapter. Two, gardens provide a place where many game animals are taken by Maya hunters. In Chapter 3, the number and kinds of game hunted in gardens were presented. Those results also will be discussed below with respect to the garden information presented here. First, however, the specific results about gardens will be discussed.

Gardeners

To the Maya, growing a garden is an ethnic identifier, separating them from all other people (Burns, 1983). While some people consider corn farming a peasant occupation, to the Maya, planting a garden is a reaffirmation of what it means to be Maya. The results of this study indicate that in small, rural villages, most adult Maya men still cultivate gardens, but the practice and cultural importance of gardening by the Maya may be decreasing.

During the early 1900s, prior to the modern era in the Yucatán Peninsula, essentially every able-bodied, adult male planted a garden (Redfield and Villa Rojas, 1962; Villa Rojas, 1987). Now, however, the proportion of people planting gardens is less than before. For example, Murphy (1990) reported that at Señor, Quintana Roo (a small Maya village about 50 km north of X-Hazil Sur), only about 83% of the adult men planted gardens. At X-Hazil Sur, about 80-85% of the adult men and widows, called *ejidatarios*, planted gardens. This decrease from 100% in the proportion of people planting gardens during modern times is consistent with a general decline in planting throughout the state of Quintana Roo as the Maya diversify their repertoire of subsistence activities to include other economic enterprises, such as timber harvest and the growing of citrus fruits for commercial sale (Sullivan, 1987).

While these results indicate a reduction in the proportion of people planting gardens, planting gardens continues to be an important cultural activity. The results indicate that Maya gardeners, as they have done for more than 100 y, still frequently work together in teams composed of friends or family members (Murphy, 1990; Villa Rojas, 1987) rather than individually plant a garden. Working together has many benefits because the various activities associated with planting are difficult, time consuming, labor intensive, and expose the gardener to the hot sun and high temperatures of the area. By working together, for example, gardeners finish the work sooner. In addition, if one of the gardeners becomes ill or decides to work elsewhere temporarily, the other partner will be able to continue caring for the garden. Thus, working together enhances the chances that the garden will be harvested in spite of unexpected events that could keep a Maya gardener from tending his crops.

The results for X-Hazil Sur also suggest that the Maya gardeners may be changing the number of gardens they plant per household per year. According to other studies in the Yucatán Peninsula, the Maya typically plant two gardens per household per year (Murphy, 1990; Villa Rojas, 1987). The results for X-Hazil Sur indicated that gardeners planted 1.2-1.3 gardens per garden group per year. While a garden group and a household are different units of measurement, they are roughly equivalent for this type of comparison. This results suggest that Maya gardeners are tending fewer fields than as recently as 60 y ago.

Gardens

Annual horticultural cycle. Gardening, as practiced at X-Hazil Sur, is similar to gardening practiced by Maya elsewhere in the Yucatán Peninsula (cf., Murphy, 1990; Redfield and Villa Rojas, 1962; Smith and Cameron, 1977; Villa Rojas, 1987). This is to be expected given the similar soils, topography, and climate of the region (Mosely and Terry, 1980).

The single most important factor affecting the annual horticultural cycle is rainfall. In order for gardens to be successful, heavy rains must begin in May or June, when gardens should be planted, and cease in November or December, when corn should be harvested. The 1989 growing season was largely a failure at X-Hazil Sur due to rains that were late in starting and less substantial than average (Figure 2-4). As a result, plantings often were delayed or were repeated as farmers tried to adjust to the unexpected conditions and still salvage a harvest. In the end, large numbers of gardeners simply abandoned their fields and the meager crops.

The impact of the hot, dry conditions in 1989 on the wildlife is unclear as several factors may have affected wildlife populations. For example, fewer workers in the gardens and unharvested crops abandoned in the gardens may have favored wildlife by reducing the number of potential hunters and increasing the amount of food potentially available to wild animals. On the other hand, a decrease in the amount of natural foods in the forest due to the dry conditions and an increase in the amount of hunting by hunters seeking to compensate for the failed gardens, for example, may have had negative impacts on wildlife populations.

The 1989 crop failure, according to X-Hazil Sur residents, was attributable to Hurricane Gilbert, the largest and strongest hurricane ever recorded by modern meteorological instruments (Anon. 1988; Wilder, 1988). This hurricane swept across the Yucatán Peninsula on 14-15 September 1988, making landfall about 175 km north of X-Hazil Sur. Strong winds and high seas caused major damage to both coastal and inland areas as the storm moved west across the peninsula. The following year, the Yucatán Peninsula suffered a serious drought. Local residents reported that extended dry seasons usually occurred after previous hurricanes in the area, but had no explanation for the phenomenon. Given the geographical position of the Yucatán Peninsula and the relatively high frequency of hurricanes and other tropical storms in the area, crop failures of this nature, such as the one after Hurricane Gilbert, probably occur every 10-20 y.

The 1990 growing season was considered about average by Maya gardeners at X-Hazil Sur. Heavy rains began in June during the customary period and continued through the growing season. As a result, crops were planted and weeded during the usual time periods. The rains lessened in December (Figure 2-4) and gardeners reported that an average corn crop was harvested.

Garden type and years of previous use. Most gardens in the Yucatán Peninsula legally can be cleared either from Late Secondary Forest or Early Secondary Forest. At Ejido X-Hazil y Anexos, gardens can not be planted in the permanent forest reserve established by the Plan Estatal Forestal. Given a choice, gardeners prefer to clear sites in Late Secondary Forest because the work is easier. Gardens also vary in the number of years that they can be planted consecutively and still produce an acceptable crop. While gardens in the Yucatán Peninsula rarely are planted more than 3 y in a row, regardless of soil fertility or the forest type of the site (Redfield and Villa Rojas, 1962), gardens planted on sites in Late Secondary Forest reportedly can be planted about 3 y in a row, while sites in Early Secondary Forest usually are changed after 1 y. This difference is due, according to Maya gardeners, to increased soil fertility and reduced weed problems (Noguez-Galvez, 1991).

The results of the present study suggest that gardeners at X-Hazil Sur are changing the types of gardens they plant and the number of times that crops are planted in these fields. According to recent studies in the region, gardeners plant two main types of gardens: One, the *chacben* garden is planted on newly cleared land in Late Secondary Forest. Two, the *hubché* garden is planted on Early Secondary Forest lands cultivated the previous year. Usually these gardeners have a single field of each type (Murphy, 1990; Edwards, 1986).

This use of two garden categories may be confusing as other studies have used additional or different terms. Redfield and Villa Rojas (1962), for example, differentiated between garden types at *Chan Kom* in 1930-1931 of the basis of the harvest number (e.g., first-, second-, or third-year) and the previous status of the site (e.g., forest or fallow garden). According to this terminology, there were about six types of gardens. Villa Rojas (1987), however, used only three categories based on research at Señor in 1935-1936. These categories were based solely on the previous status of the site and were named as follows: *chacben* (planted in virgin lands), *zacab* (planted in soils used 1-2 y before), and *hubché* (planted in soils fallowed for 7-8 y). This variety of terms, rather than suggesting a multitude of garden types, probably represents regional or temporal differences in terminology.

Gardeners at X-Hazil Sur differed from those gardeners at Señor or Chan Kom in two aspects from this pattern of planting one old garden and one new garden: One, about 91-98% of the gardens at X-Hazil Sur were on new sites, rather than about 50%, as would be expected when single gardens of each of the two types are planted. Two, about 99% of the gardens at X-Hazil Sur were cleared from Early Secondary Forest and would correspond to the *hubché* category, rather than about 50%, as would be predicted based on the other studies. These results were roughly similar to those obtained by Noguez-Galvez (1991) during a separate study of soils at X-Hazil Sur. Thus, Maya gardeners at X-Hazil Sur typically are planting a new garden in Early Secondary Forest every year. As mentioned above, the reason for using Early Secondary Forest is not biological, rather it is due to *ejido* and state forestry rules that proscribe clearing Late Secondary Forest for gardens.

Gardeners at X-Hazil Sur also differed from other indigenous people in that they apparently did not actively manage the forest or garden fallow, as has been reported elsewhere in Mexico. For example, traditional Maya practiced several silvicultural techniques, including the *pet kot* (vegetation enclosed within a wall of stones) and *tolché* (forested belt around gardens; Gómez-Pompa, 1987a, 1987b; Gómez-Pompa et al., 1987). Another form of forest management called the *te'lom* has been described for the Huastec Maya in northeastern Mexico (Alcorn, 1984a, 1984b). A *te'lom* is a group of useful trees situated on steep slopes and ridges. Some of these trees occur naturally, while others are transplanted from other gardens. While only a minimum of weeding occurs, the permanence of the site and the accumulated benefits of weeding and care over several years tend to favor the useful species. Neither Rewald (1989) nor Murphy (1990) observed these silvicultural techniques at Señor. Likewise, none of these practices was observed at Ejido X-Hazil y Anexos during 1989-1990.

Size. Several factors can influence the size of the field that a gardener will plant, including: soil fertility, number of helpers, weather conditions, family size of the gardener, age and health of the gardener, availability of suitable lands, time available to clear and plant, frequency and severity of crop predation by wildlife, and number of domestic animals that also must be fed. Hypothetically, a Maya gardener would plant the largest garden that he could successfully manage as this would provide abundant food to eat or sell. At X-Hazil Sur and generally throughout the Yucatán Peninsula, however, there is little incentive to produce an excess of crops. Crop storage, for example, is a problem due to insects and crop predators (Villa Rojas, 1987). Also, rural Maya people generally do not buy large amounts of food on a regular basis, but instead use their cash to buy clothes and durable goods. While garden size may vary among families, the most important consideration is that a gardener must have a large enough garden to meet the needs of his family.

Considering how weather, crop predation, and economic practices can vary over time and from region to region, it is remarkable that garden size apparently has varied little over the past 60 y in the Yucatán Peninsula. Redfield and Villa Rojas (1962), for example, reported average garden sizes of 2.9 ha (1930; $\underline{n}$ = 52 gardens) and 2.5 ha (1931, $\underline{n}$ = 46 gardens). Villa Rojas (1987) reported average garden sizes of 1.5-2.3 ha ($\underline{n}$ = 52 informants, each with 1-3 gardens; combined total of 4.7 ha of gardens per informant), depending on the type of garden. Murphy (1990) reported average garden sizes of 1.9 ha for old gardens and 2.9 ha for new gardens, for a total of 4.8 ha per household ($\underline{n}$ = 59 households). At X-Hazil Sur, the average garden size was 2.1 ha in 1989 and 2.7 ha in 1990. These values were very similar to the average garden sizes cited above and suggest that garden size varies little from year to year and region to region in the Yucatán Peninsula.

Based on the 1989 garden data for X-Hazil Sur, the total amount of land used as gardens on the *ejido* was about 5.45 km^2 (ca. 1% of the total study area). This was substantially less than the figure of 33.56 km^2 presented in Table 2-3 that was based on information provided by the Plan Estatal Forestal. While the reasons for this difference are not clear, it is possible that the photo-interpretation did not clearly differentiate between active gardens (*milpas*) and previously active gardens (*acahuales*). This would be highly possible given the small size of gardens (1-3 ha), large scale of aerial photographs (1:37,000), and the time of year when the aerial photographs were taken. According to the information on the aerial photographs, the flights were conducted in February, about 3-4 months prior to the planting season. This likely contributed to an overestimate of the area in gardens because at that time old and new gardens would have a similar appearance and would be hard to differentiate without resorting to complex laboratory analyses.

Distance from X-Hazil Sur. In the Yucatán Peninsula, most Maya live in small rural villages and plant their gardens in forests on the outskirts of the village (Villa Rojas, 1987). As villages have increased in size, however, the amount of unoccupied land near settlements and available for horticulture has decreased. As a result, Maya gardeners have had to clear gardens at increasingly greater distances from the village.

The distance that a gardener must travel to reach the field site is important because of the high frequency of visits he must make to manage the garden. In addition, the gardener must transport his crops from the garden to his home. Gardeners today usually walk or ride a bicycle on their almost-daily visits to the field, but as recently as the 1960s gardeners at X-Hazil Sur used horses and mules to meet their daily transportation needs (A. Poot Yam, pers. comm.). Few Maya gardeners have access to trucks for daily use. Under optimal conditions, a gardener on bicycle following a dirt trail through the forest might take 20-30 min to cover 3 km, but travel time can increase substantially when it is muddy or a load must be carried. Thus, it is highly advantageous for a gardener to minimize the distance to the field.

At X-Hazil Sur, the majority of gardens were near the village, but gardens also were distributed in other areas of the *ejido*, except in the permanent forest reserve east of Mexico Highway 307. While the average garden distances at X-Hazil Sur were 4.0 km in 1989 and 3.8 km in 1990, about 50% of the gardens were at 1.0-2.9 km from the village, but gardeners also planted fields up to 16.6 km away. Perhaps the main reason for this widespread distribution of gardens is that the *ejido* is well-supplied with roads and trails that greatly facilitate access to garden sites (Figure 2-5). For example, Mexican Highway 307 crosses the *ejido* from north to south and the Pemex roads promote travel in the southern part of the area. As can be observed from Figure 2-5, the vast majority of gardens are within 2 km of these roads. These roads and trails greatly ease the work associated with reaching the gardens.

Crops planted. Among the several studies of Maya gardening practices, a common observation is that the Maya plant a wide variety of crops. Redfield and Villa Rojas (1962), for example, reported that gardeners in Chan Kom mainly planted corn, but also cultivated beans, squash, *jícamas*, sweet potatoes, and chile, for a total of six crops. Villa Rojas (1987) indicated that gardeners at Señor planted 11 types of crops in their fields, and that corn, beans, and squash were most frequently cultivated. Murphy (1990) reported nine crops at Señor in a later study; again, corn, beans, and squash were most frequently planted.

The number of types of crops planted by gardeners at X-Hazil Sur was greater than reported for other Maya gardeners. In 1989, gardeners at X-Hazil Sur reported planting 16 types of crops, while in 1990, 13 types were reported. Corn (99% of gardens in 1989 and 100% in 1990), kidney beans (48% and 75%), and squash (63% and 84%), as reported for other Maya gardens and by Noguez-Galvez (1991) in a separate study at X-Hazil Sur, were still the most frequently planted crops.

The additional crops in gardens planted at X-Hazil Sur probably do not represent an expansion of the Maya diet because these crops traditionally have been cultivated by the Maya elsewhere in the Yucatán Peninsula (Nations and Nigh, 1980; Smith and Cameron, 1977). Rather, the appearance of additional crops in gardens probably represents an improvement in reporting practices by researchers. Previously, certain crops that were planted in small quantities or that required special attention were cultivated only in special plots called *pet kot* (Gómez-Pompa et al., 1987) and *ka'anche* (Barrera, 1980; Vargas Rivero, 1983). These specialized studies may have overlooked the fact that gardeners planted these crops in their regular gardens, too.

While 16 types of crops were available to gardeners at X-Hazil Sur, not all gardeners planted all of these potential crops in their gardens every growing season. The average number of crops per garden was 5.9 in 1989 and 3.9 in 1990, but up to 11 crops were planted in a single garden. This suggests that gardens can be extremely diverse with respect to crops. These averages and ranges were substantially higher than reported elsewhere for Maya gardeners in the Yucatán Peninsula. In the only other study where specific crops were indicated for individual gardens, Redfield and Villa Rojas (1962) reported that the average number of crops per garden was 2.0 (n = 53 gardens, SE = 0.16, range = 1-5 crops per garden). One possible explanation for this difference is that gardens at X-Hazil Sur were culturally different from other Maya and traditionally planted a more diversified garden. A better explanation, however, is that the use of *pet kot* and *ka'anche* plots now is declining (Gómez-Pompa et al., 1987) and that certain types of crops that formerly were planted only in those plots now also are being planted in gardens.

Crop phenology. Based on 1990 data, crops at X-Hazil Sur were present in gardens only about five months during the year, July-November. Gardens contained primarily seedlings during the first part of the growing season. Corn, for example, was at the seedling stage during July-August (Figure 6-6), while kidney beans were at the seedling stage well during July-October (Figure 6-7). Most crops matured rapidly, however, and by the end of December, all had been harvested.

Density and mortality of crops. Although the density of crops varied greatly between gardens at X-Hazil Sur, a substantial amount of crops were potentially available to wildlife. The average density of crops varied greatly between gardens (45.8-179.0 stalks/m^2; Table 6-1). Gardens primarily were composed of corn (86% of stalks), beans (5%), and squash (3%). Seedling mortality was relatively high for squash (82% of seedlings) and kidney beans (62%), however, and compared with corn (21% mortality) few mature plants survived to be harvested. All three of these crops were eaten by wildlife (see Chapter 5).

Wildlife Use of Gardens and Adjacent Forest

Crop predation. In this study, crop predation was used as one measure to quantify the degree and seasonality of wildlife use of gardens and crops. Given that hunters also hunt in their gardens to obtain game and to protect crops, crop predation might also explain some of the variation in game harvest patterns.

Fourteen taxa of wild animals were identified as crop predators for gardens at X-Hazil Sur. Birds (e.g., Psittacidae, Corvidae, Icteridae, and Columbidae) were the main crop predators in 1989 (50% of gardens), while in 1990, the coati (30%) and collared peccary (23%) were identified as the main crop predators. In one of the few studies that specifically mentions crop predation in the Yucatán Peninsula, Murphy (1990) reported that white-tailed deer and paca ate crops at the village of Señor.

Wildlife tracks. Few track sets were recorded for the track slicks along gardens and transects. This corresponded with the low sighting rate for animal censuses (see Chapter 4). Some of the 17 taxa of wild animals represented on the slicks also were taken by hunters (see Chapter 3) while other taxa were observed only during animal censuses (see Chapter 4). Based on the number of track sets recorded, the armadillo (a nongame species, 32 track sets) and the agouti (a game species, 21 track sets) were the most abundant animals. Neither of these two taxa, however, were reported as crop predators (see Figure 6-9).

Use of gardens versus adjacent forest. Although the paired comparisons of track sets in slicks along gardens and transects yielded only limited results, a few conclusions can be made. In Late Secondary Forest with Gardens, the total number of track sets (29 versus 11), as well as the number of taxa (8 versus 4) observed were greater in garden track slicks than in transect track slicks, respectively, by a ratio of more than two to one (Table 6-2). In Early Secondary Forest, however, the total number of track sets (21 versus 19) and number of taxa (8 versus 9) observed were about equal between garden and transect track slicks. This suggests that in Late Secondary Forest with Gardens, there was a substantial difference in wildlife use of gardens versus transect, but that in Early Secondary Forest wildlife use of gardens and transects was similar.

Variation in wildlife use by vegetation type. The relative abundance of tracks sets suggests differences in animal abundance among vegetation types. Late Secondary Forest with Gardens had the highest ratio of track sets per reading at 1.05 (40 track sets per 38 readings), followed by Early Secondary Forest at 0.82, and Late Secondary Forest without Gardens at 0.33 (Table 6-2). One possible explanation of this is that the mixture of gardens and forests provides more food and cover for wildlife than either forests alone or the combination of gardens, fruit and vegetable plots, former gardens, cattle corrals, and pastures.

Monthly variation in wildlife use of gardens and adjacent forest. The monthly frequency of track sets along gardens and transects were similar in that tracks were relatively frequent in the wet season during 7/90-10/90 (93% of track sets) and infrequent as the wet season ended and the dry season began during 11/90-1/91 (Figure 6-10). One possible explanation is that wildlife use of gardens was greater during the period between planting and harvest because of the availability of crops as food. After harvest there was no little or no food available in the gardens to attract the wildlife.

A second explanation about the monthly differences in track set frequency is that juvenile animals accompanied their mother during part of the year. This would inflate population densities as two animals were occupying an area that one normally would hold.

A third explanation is that wild animals may have restricted their activities in response to the increased number of adult men tapping sapodilla trees. While *chicle* is tapped during July-March at the study area, the majority of *chicle* is harvested during September-January (Barrera de Jorgenson, 1993). During 1989 at Ejido X-Hazil y Anexos, 311 *chicleros* (*chicle* tappers) harvested this product, while in 1990, 333 *chicleros* were active on the *ejido*. Most *chicleros* commuted daily between their home and work site. Since the sapodilla tree primarily is located in Late Secondary Forest, the density of *chicleros* was about 0.66 *chicleros*/km^2 Late Secondary Forest (322 *chicleros*/489.48 km^2; Table 2-3). Given the intensity and duration of these disturbances associated with *chicle* tapping, many species of wildlife may either have sought refuge in isolated areas without sapodilla trees or severely limited their activity during 10/90-1/91, for example, foraging during the night when *chicleros* were not working.

Game harvest in gardens. Although areas categorized as Plots & Gardens composed only 6.1% of the study area, the number of wild animals harvested in those areas by Maya hunters was proportionally higher than expected for 10 of 12 game species (Table 3-3). The top five game taxa most frequently taken in Plots & Gardens were the white-tailed deer (62.5% of individuals taken were harvested in Plots & Gardens, $n = 26$ deer kills), ocellated turkey (*Agriocharis ocellata*; 50.0%, $n = 6$ kills), agouti (48.6%, $n = 35$ kills), coati (46.7%, $n = 167$ kills), and pocket gopher (*Orthogeomys hispidus*; 41.5%, $n = 53$ kills). Only the white-lipped peccary (three individuals taken during a single outing) and the thicket tinamou (*Crypturellus cinnamomeus*; not known to use gardens or eat crops) were not taken in gardens.

Indigenous people throughout South America explicitly recognize that a function of gardens is to attract game for hunting (Dufour, 1990). Crops and the surrounding vegetation are especially attractive to deer, peccary, and rodents. Some indigenous groups, such as the Ka'apor and the Kuikuru of Brazil, respond to crop predation by planting more crops than necessary for their personal consumption (Balée, 1984; Balée and Gély, 1989; Carneiro, 1983). Other groups, such as the Kayapó (Parker et al., 1983; Posey, 1982, 1983, 1984), disperse their gardens throughout the area.

Indigenous groups in Mesoamerica also recognize that gardens can attract game. In southern Mexico, for example, Lacandon Maya farmers leave a portion of their corn harvest standing in the field (Nations and Nigh, 1980). This enables hunters to harvest wild animals such as the deer, squirrels, pacas, coatis, and peccaries attracted to the corn. In Nicaragua, wild animals such as pacas, agoutis, white-tailed deer, collared peccaries, and Baird's tapir (*Tapirus bairdii*) are major crop pests in Miskito Indian gardens (Nietschmann, 1973). Paca and white-tailed deer are frequently harvested in gardens and plantations by Miskito hunters.

Wildlife densities in three forest successional stages. Due to small sample sizes, wildlife population density estimates could not be determined for all species and vegetation types. Instead, sighting frequencies were calculated for three forest successional stages: Late Secondary Forest without Gardens, Late Secondary Forest with Gardens, and Early Secondary Forest. Statistical comparisons could be made for four species. Significant differences were detected for plain chachalaca (*Ortalis vetula*) sighting frequencies between the three stages (χ^2 approximation = 8.4900, d.f. = 2, P = 0.0143; Table 4-1). No significant differences in sighting frequencies were detected between forest successional stages for squirrels (*Sciurus* spp.; P = 0.1596), coatis (P = 0.0877), or kinkajous (*Potos flavus*; P = 0.0665). When summarized by game versus nongame taxa, significant differences were detected for game bird sighting frequencies between the three forest stages (χ^2 approximation = 7.2947, d.f. = 2, P = 0.0261; Table 4-1). The greatest average sighting frequency was 5.8 sightings per 10,000 km in Early Secondary Forest. No significant differences in sighting frequencies were detected between forest successional stages for game mammals ($\underline{P}$ = 0.1972), nongame mammals ($\underline{P}$ = 0.1752), or nongame birds ($\underline{P}$ = 0.1994).

While it may be premature to speculate on these data, it appears that there was little difference in sighting frequencies of wildlife between three forest successional stages at Ejido X-Hazil y Anexos. Although sample sizes were small, it appears that the wildlife was using each of the three forest successional stages and not selecting for or against any of the three stages. This suggests that all three stages collectively or any one stage individually could be sufficient to ensure the survival of the wildlife on the study area.

Crops and game food habits. Of the several crops planted in gardens at Ejido X-Hazil y Anexos, only six taxa were recorded as being consumed by game species. Corn was most frequently taken by wild animals and occurred in 25.4% (frequency of occurrence) of 284 game stomachs that were analyzed during June 1989-October 1990 (Table 5-2). Squash was the second most frequently taken crop (6.0% of stomachs), while sweet potato, kidney bean, yuca, and the category other/zacate occurred in ≤ 3.2% of stomachs each.

Of the 12 game species, 10 consumed crops at Ejido X-Hazil y Anexos; crops were not recorded for the white-lipped peccary (three stomachs analyzed), and no pocket gopher stomachs were analyzed (contents could not be identified visually). By frequency of occurrence (each species considered separately), the ocellated turkey most frequently consumed crops (80.0% of stomachs; Table 5-2). The frequency of crop consumption for the remaining nine game species (excluding the pocket gopher), in declining rank order, was as follows: agouti (50.0% of stomachs), paca (41.7%), coati (40.3%), thicket tinamou (33.3%), great curassow (*Crax rubra*; 30.8%), collared peccary (24.1%), brocket deer (*Mazama americana*; 12.5%), white-tailed deer (9.1%), and plain chachalaca (4.8%).

These results suggest that, by frequency of occurrence in game stomachs, most crops were of little or no importance to game diets. Corn, however, was relatively important. Corn also was the most frequently planted crop. While the relative importance of corn in game diets may suggest selection by these game species for nutritional reasons, it could also mean that game animals are simply consuming corn because it is relatively easy to find in gardens.

These results also indicate that game species vary in their consumption of crops. Some species, such as the ocellated turkey and agouti, frequently consumed crops, while others either infrequently consumed crops or consumed none at all. While it is possible that many game animals were shot in gardens before they had the opportunity to consume any crops, it also is possible that they were consuming noncrops while in the gardens (see Chapter 5 for additional information about game diets).

CHAPTER 7
SYNTHESIS AND CONCLUSIONS

In this dissertation I have presented information about subsistence hunting by Maya Indians at Ejido X-Hazil y Anexos, Quintana Roo, Mexico. These Indians have hunted and planted gardens in the Yucatán Peninsula for several thousand years. That both of these practices continue today, after 50-100 y of acculturation, indicates that hunting and gardening are important elements of Maya culture. Maya subsistence hunting was studied to test the hypothesis of garden hunting. Linares (1976) described garden hunting as a game-procurement system where hunters specialized in certain species of terrestrial mammals whose population density was greater in the vicinity of gardens than in forested areas without gardens. According to Linares (1976), the densities of these species were greater because they ate garden crops and they were tolerant of human disturbances. As a consequence of their eating crops, these terrestrial mammals tended to occur through out the year in the vicinity of gardens planted by the hunters. This behavior resulted in a higher biomass of these species in the vicinity of the gardens than in the adjacent forest. In view of this higher density of game in the vicinity of gardens than in the forest, hunters shifted their hunting practices from sites in tropical forests to garden sites in order to focus primarily on those species of terrestrial mammals that occurred in the vicinity of gardens. Garden hunting, according to Linares (1976), resulted in the substitution of a naturally occurring wildlife community present in the area on a seasonal basis for a culturally created community of terrestrial mammals present in the area throughout the year.

Garden hunting, according to Linares (1976) was based on several premises: one, wild animals taken as game by hunters occurred in gardens and the garden-forest ecotone; two, hunters focussed their harvest of game on those species of wild animals that used gardens; three, the densities of these game species were greater in the vicinity of gardens than in forests without gardens; and four, these wild animals consumed crops from gardens. This study was designed to test each of these premises.

Game Harvest and Wildlife Use of Gardens

Maya hunters at X-Hazil Sur harvested eight species of game mammals and four species of game birds. Game inventories were compiled by living at X-Hazil Sur and interviewing hunters immediately after they returned from a hunt (see Chapter 3). This encouraged hunters to report the game they harvested and facilitated accurate measurements of the game taken.

Among the game harvested, the coati (*Nasua nasua*, n = 167 individuals taken during June 1989-October 1990), pocket gopher (*Orthogeomys hispidus*, n = 53), and paca (*Agouti paca*, n = 47) were the most frequently taken mammals, whereas the plain chachalaca (*Ortalis vetula*, n = 167) was the most frequently taken bird (Table 3-1). Hunters did not take several other potential game species, including insects, reptiles, and amphibians, which are widely eaten by other indigenous people in forested Neotropical areas, or other mammals such as the tapir (*Tapirus bairdii*), armadillo (*Dasypus novemcinctus*), or primates (*Ateles geoffroyi* and *Alouatta palliata*). This indicates that Maya hunters at X-Hazil Sur are taking a limited number of taxa from all of the species found in the area.

Except for the white-lipped peccary (three individuals taken during a single outing), all game birds and mammals at Ejido X-Hazil y Anexos were taken at least some of the time in areas categorized as Combined/Early Secondary Forest. These areas were composed of gardens, former gardens, and fallowed areas that were reverting to forest. Eight game taxa were taken ≥ 50% of the time in these areas (Table 3-7): pocket gopher (94.3% of kills in Combined/Early Secondary Forest, n = 53 kills), plain chachalaca (94.0%, n = 167), white-tailed deer (83.3%, n = 26), agouti (68.6%, n = 35), ocellated turkey (66.7%, n = 6), paca (65.9%, n = 47), coati (55.1%, n = 167), and brocket deer (50.0%, n = 16). These high proportions of game taken in areas categorized as Combined/Early Secondary Forest show that most of the game birds and mammals harvested by Maya hunters at X-Hazil Sur used gardens and the disturbed areas in the vicinity of gardens.

The high proportion of game taken in the vicinity of gardens at Ejido X-Hazil y Anexos also has been noted in other studies of hunters/horticulturalists. In a study of the Runa Indians in Ecuador, Irvine (1987) determined that hunters concentrated on game species that occurred in gardens and adjacent fallows and infrequently harvested game that occurred in the forest. In a study of Agta hunters and Palanan farmers in the Philippines, Peterson (1981, 1982) also determined that hunters concentrated on game species that consumed garden crops. In a study of Efe hunters and Lese horticulturalists in the Ituri Forest of Zaire, Wilkie (1989) also reported that regrowth forest surrounding horticulturalists' villages can and do provide substantial quantities of game. There were two key elements to each of these studies: One, the farmers/gardeners continually cleared new garden sites from the surrounding forest and abandoned old garden sites. Two, the vegetation of the areas was a mixture of crop fields, forest edges, and broken cover. Peterson (1981:20) concluded that farming expansion, at the level encountered in the Philippines, appeared to be supporting a high density of game rather than causing environmental destruction.

Wildlife Densities

Linares' (1976) third premise for garden hunting was that the densities of game animals were greater in the vicinity of gardens than in forests without gardens. Data on wildlife densities were obtained by conducting censuses along transects in three successional stages of forest; Late Secondary without Gardens, Late Secondary Forest with Gardens, and Early Secondary Forest (see Chapter 4). Censuses were conducted during March-November 1990. This period included one growing season, but not a complete year.

Relatively few animals were sighted during the 121 censuses (ca. 240 km and 244 h, Appendix J). A total of 240 sightings were made (150 mammals and 90 birds). More than 50% of the taxa were sighted by census number 22, where as no new taxa were sighted after census number 75. This suggests that the censuses recorded most of the potential game birds and mammals at the study area.

Among the birds and mammals sighted, seven mammalian taxa and three avian taxa were game species. However, only the coati and plain chachalaca, among game species, were sufficiently abundant to calculate densities and compare sighting frequencies between forest successional stages. The coati had a population density of 1.0 individuals/km^2 in Late Secondary Forest without Gardens and 3.9 individuals/km^2 in Late Secondary Forest with Gardens (Table 4-2). No coatis were sighted in Combined/Early Secondary Forest. The plain chachalaca had a population density of 8.7 individuals/km^2 in Late Secondary Forest without Gardens, 2.4 individuals/km^2 in Late Secondary Forest with Gardens, and 20.3 individuals/km^2 in Combined/Early Secondary Forest (Table 4-2). Due to small sample sizes, it was not possible to compare densities statistically, however, it was possible to compare average sighting frequencies. Average sighting frequencies were significantly different among three forest successional stages for the coati ($\underline{P}$ = 0.0877) and the plain chachalaca ($\underline{P}$ = 0.0143; Table 4-1). Coatis were more frequently sighted in Late Secondary Forest with Gardens, whereas plain chachalacas were more frequently sighted in Combined/Early Secondary Forest.

Given the nature of these data, animal taxa were lumped into four categories of game versus nongame birds and mammals in order to generalize about wildlife densities. For game mammals, nongame mammals, and nongame birds, there were no significant differences in average sighting frequencies among the three forest successional stages ($\underline{P}$ > 0.05). Only those taxa categorized as game birds, primarily plain chachalacas, exhibited significant differences in average sighting frequencies among the three forest successional stages ($\underline{P}$ = 0.0261; Table 4-1). This indicates that even for broad groups of animals, there generally were no significant differences detected in average sighting frequencies among forest successional stages.

This general absence of significant differences in average sighting frequencies among forest successional stages for bird and mammals species, taxonomic groups, and game and nongame birds and mammals may be due to small sample sizes (e.g., too few censuses to conducted statistical analyses) and experimental design problems (e.g., the transects may have been too close together). However, it is highly possible that in fact there were no differences in wildlife densities between forest areas in the vicinity of gardens and forest areas not in the vicinity of gardens, as had been proposed by Linares (1976). This might be expected given the low human population density (ca. 3.0 people/km^2), high degree of habitat interspersion, and ecological characteristics of the wild animals that occur at the study area (see Chapter 2).

The lack of significant differences in game population densities among forest successional stages determined at Ejido X-Hazil y Anexos also has been noted in other areas. Wilkie and Finn (1990) studied densities for 19 species of terrestrial mammals at the Ituri Forest and determined that (1) only three species were less dense in post-agricultural forest and (2) small duikers (*Cephalophus* spp., Bovidae Family), although an important source of food for humans, seemed unaffected by forest clearing for subsistence farming. Wilkie and Finn (1990) indicated, however, that habitat loss or hunting pressure had reduced the abundance of larger ungulates near villages. This would suggest that game species at X-Hazil could sustain limited levels of horticulture and hunting without experiencing differences in their population densities among forest successional stages, but that increased levels could negatively affect the larger species.

Consumption of Garden Crops by Game Species

Linares' (1976) fourth premise was that the game species taken by hunters would consume crops from the gardens. At X-Hazil Sur, 16 taxa of crops were planted, but not all gardens had all 16 crops. Corn, kidney beans, and squash were the three most frequently planted crops. Corn was planted in 99% of the gardens during 1989 ($\underline{n}$ = 150 gardens) and 100% of the gardens in 1990 ($\underline{n}$ = 40 gardens; Figure 6-4). Squash and kidney beans also were planted in most gardens during 1989 and 1990. Crops generally were available in gardens between May, the beginning of plant season, and January, the end of the harvest season (Figure 6-1).

Six crops were frequently consumed by game species. Corn was most frequently consumed (25.4% of 284 stomach samples), but squash (6.0%), other/zacate (3.2%), sweet potato (2.8%), kidney bean (1.4%), and yuca (0.3%; Table 5-2) also were eaten by game taxa. Corn, squash, and other/zacate, including crops from the currents and previous growing seasons, were consumed throughout the year by game species, whereas the other three crop species were consumed only during January-April, when gardens were being cleared and burned (Table 5-3). Thus, whereas corn was the crop taxa most frequently consumed by game species, 6 of the 16 crops planted in gardens were eaten.

Four game species were the primary consumers of crops: paca, agouti, coati, and collared peccary (Tables 5-4 and 5-5). These four taxa composed four of the top six game species harvested by number of individuals (rank order 1, 4, 5, and 6) and by total body weight (rank order 2, 3, 4, and 6; Table 3-1). This indicates that at Ejido X-Hazil y Anexos some of the most frequently taken game species were major consumers of crops and supports one of Linares' (1976) assumptions.

In conclusion, these data suggest that Maya Indians at Ejido X-Hazil y Anexos did not practice garden hunting, where the biomass of game, it is proposed, is increased and able to offset the loss due to hunting. Rather, the data suggest that gardens are acting as a sink (cf., Pulliam, 1988; Pulliam and Danielson, 1991) and that Maya hunters are taking as game those species that occasionally feed on crops.

In order to help develop wildlife management plans for the area, it would be important to calculate wildlife production and potential harvest for the main game species (Redford, 1992). Productivity is measured by calculating population density and reproductive rate (cf., Eisenberg and Seidensticker, 1976; Eisenberg et al., 1973). Robinson and Redford (1991c) proposed a model to calculate production using three elements: (1) population density at carrying capacity, (2) the maximum rate of population increase, and (3) the density that produces the maximum sustainable yield. Unfortunately, the production and potential harvest values calculated by Robinson and Redford (1991c) are not directly applicable to the present study because the average densities they used were at least 10 times greater than those at Ejido X-Hazil y Anexos. Additional census and reproductive data are necessary to determine potential harvest levels.

Of Linares' (1976) four premises, three were supported: one, wild animals clearly used gardens; two, hunters concentrated their hunting on those animal species that occurred in gardens; and three, game species consumed crops found in gardens. The X-Hazil data, however, did not support the model of garden hunting with respect to wildlife densities. Linares (1976) predicted that game species taken by garden hunting would have greater densities in the vicinity of gardens than in forests without gardens. Hunters at X-Hazil Sur commonly reported that many game species were more abundant in the vicinity of a garden than at forested sites away from gardens. This study, however, generally did not find differences in the density of wildlife in the vicinity of gardens as compared with their densities in forest areas without gardens.

Closing Comments

Given the nature and extent of subsistence hunting by Maya Indians at Ejido X-Hazil y Anexos, the harvest of some game species likely can continue for the indefinite future. Population levels of the coati, plain chachalaca, pocket gopher, paca, collared peccary, and agouti appear to be stable. For the white-tailed deer, brocket deer, thicket tinamou, great curassow, and ocellated turkey, population levels do not appear to be stable, and hunters frequently complained that these species had noticeably declined in number during the past 20-30 y. Hunters also reported that previously they used to hunt primates (*Ateles* and *Alouatta*) and the crested guan (*Penelope purpurascens*), but that these three species now were so hard to find that they almost never were hunted.

Presently there are no effective environmental education or wildlife management programs underway at the study area. As a result, hunters harvest game without regard to age or sex of the prey. If the local wildlife populations are to remain viable, effective education and management programs must be implemented. Recognizing the independent nature of many Maya Indians with respect to government regulations and prohibitions, this may be difficult. However, education and management programs are presently being used by local officials and state forestry managers to regulate the harvest of timber and chicle, the latex of the sapodilla tree (*Manilkara zapota*; cf., Barrera de Jorgenson, 1993). I would strongly suggest that Mexican wildlife officials establish a wildlife management program that is similar to the forestry program and is designed to accommodate the special situation of Mexican *ejidos*. Such an arrangement could include bag limits, established seasons, and areas on the *ejido* were hunting would be prohibited. At the same time, conservationists and education officials could institute activities in the local schools and villages. These educational activities should be based on species familiar to the Maya. Such a plan likely could assure the continued survival of the game birds and mammals at Ejido X-Hazil y Anexos as well as the cultural traditions of the Maya Indians that have subsisted on these species for millennia.

APPENDIX A
TEMPERATURE (°C) AND PRECIPITATION (MM) AT X-HAZIL
SUR, QUINTANA ROO, MEXICO, DURING JULY 1989-DECEMBER 1990

	July 1989			August 1989			September 1989		
Date	TMin[a]	TMax[b]	Precip[c]	TMin	TMax	Precip	TMin	TMax	Precip
1				22	34	9.0	23	35	M
2				22	37	5.0	24	36	M
3				23	32	2.0	23	37	4.4
4	23	35	M[d]	23	34	0.0	23	35	0.0
5	23	36	0.0	23	31	0.0	23	36	0.5
6	24	34	M	19	31	11.0	23	34	0.5
7	24	34	1.0	22	35	0.0	24	37	1.0
8	22	36	3.2	23	36	0.0	24	37	0.1
9	21	35	0.2	23	35	4.0	24	33	7.0
10	21	33	0.3	22	35	0.0	24	35	0.2
11	25	34	0.0	24	36	0.0	24	36	80.0
12	24	37	0.0	24	35	4.8	23	33	4.0
13	24	36	0.0	23	35	0.0	23	34	18.5
14	22	37	0.0	23	33	8.5	24	33	3.6
15	22	37	0.0	23	33	0.0	25	30	23.0
16	23	38	0.0	24	34	4.8	24	32	6.5
17	24	37	0.0	24	34	0.2	24	33	22.6
18	24	37	0.0	24	35	24.0	24	35	0.3
19	24	38	0.0	24	36	12.5	24	33	0.1
20	24	38	0.0	23	35	0.3	24	34	1.0
21	24	38	0.0	24	34	6.0	24	29	4.1
22	23	38	0.0	25	34	0.0	25	31	0.1
23	23	37	0.0	24	35	M	24	32	4.0
24	24	38	M	24	35	M	25	31	47.0
25	23	34	40.0	23	35	10.5	24	36	0.0
26	23	34	40.0	23	30	15.0	24	33	0.0
27	22	31	24.5	24	34	0.7	24	32	2.8
28	23	30	82.0	24	36	0.3	24	30	33.0
29	23	30	20.5	24	35	0.0	24	32	2.2
30	24	31	19.0	24	35	0.0	24	32	4.0
31	24	34	0.0	23	36	0.0			
Average	23.2	35.3		23.2	34.4		23.9	33.5	
Total			230.7			118.6			270.1

[a] TMin = Daily minimum temperature.
[b] TMax = Daily maximum temperature.
[c] Precip = Precipitation.
[d] M = Mist (< 0.1 ml).

Date	October 1989			November 1989			December 1989		
	TMin[a]	TMax[b]	Precip[c]	TMin	TMax	Precip	TMin	TMax	Precip
1	24	33	3.2	19	31	0.0	20	32	10.0
2	23	33	7.0	20	31	0.0	20	28	1.5
3	24	32	17.5	23	32	4.3	20	26	0.3
4	24	33	4.6	21	28	23.0	19	32	0.0
5	23	33	0.0	23	30	0.1	16	28	0.0
6	23	33	0.0	19	31	0.0	16	29	1.6
7	23	33	2.2	21	31	0.9	21	30	3.5
8	24	32	0.9	21	32	0.0	21	31	15.0
9	23	33	3.0	22	32	11.0	20	24	0.4
10	23	31	1.0	21	29	16.0	14	24	0.1
11	23	31	1.0	22	28	0.5	14	30	0.0
12	23	33	0.0	22	28	0.5	19	23	1.8
13	23	32	0.0	22	32	0.0	21	25	0.0
14	22	31	0.0	22	31	0.0	19	28	1.6
15	23	33	0.0	21	30	0.0	19	29	5.0
16	23	32	0.0	22	31	4.0	21	30	0.3
17	23	34	0.0	21	26	13.5	19	30	0.0
18	23	34	7.0	21	29	8.0	19	31	0.0
19	22	24	0.2	24	30	0.1	19	30	0.0
20	22	22	0.0	23	30	0.7	19	30	0.0
21	21	23	0.0	22	31	0.0	20	30	0.0
22	19	30	0.0	20	30	0.0	18	30	0.0
23	18	29	0.0	20	31	9.0	19	20	0.5
24	19	30	0.0	21	30	0.5	11	17	0.0
25	19	32	2.8	21	32	0.7	12	23	0.0
26	19	32	0.0	22	30	3.4	12	23	0.0
27	19	32	0.0	24	31	0.0	9	26	0.0
28	19	32	0.0	21	31	11.0	14	27	M
29	18	32	0.0	21	29	2.0	13	29	0.7
30	18	32	0.0	22	23	0.2	19	31	0.1
31	18	32	0.0				20	30	0.0
Average	21.4	31.2		21.5	30.3		17.5	27.4	
Total			50.4			109.4			42.4

[a] TMin = Daily minimum temperature.
[b] TMax = Daily maximum temperature.
[c] Precip = Precipitation.
[d] M = Mist (< 0.1 ml).

	January 1990			February 1990			March 1990		
Date	TMin[a]	TMax[b]	Precip[c]	TMin	TMax	Precip	TMin	TMax	Precip
1	19	31	0.5	20	30	0.0	20	31	0.7
2	19	29	M	20	30	0.0	17	31	0.0
3	17	29	17.0	19	30	M	20	31	0.5
4	21	28	0.8	19	32	0.0	20	30	0.0
5	21	30	5.2	18	30	0.9	18	32	0.0
6	20	30	0.5	22	29	0.9	18	32	M
7	20	30	0.0	22	31	0.0	20	32	6.0
8	20	29	0.0	19	31	0.0	20	31	0.4
9	19	30	0.5	19	31	0.0	19	31	15.5
10	19	30	0.0	19	33	0.0	20	30	0.4
11	19	29	2.0	21	31	0.0	23	30	4.0
12	20	27	2.2	17	29	0.4	22	31	0.0
13	20	27	21.0	19	31	0.0	19	32	0.0
14	19	26	0.4	19	32	0.0	19	31	0.3
15	18	27	4.0	21	34	0.0	25	33	0.0
16	20	29	0.9	22	33	0.0	25	32	67.0
17	20	29	0.0	21	33	0.0	25	32	67.0
18	20	29	0.7	20	32	0.0	19	28	0.7
19	21	29	3.0	23	32	0.0	20	32	16.5
20	20	29	1.6	17	31	0.0	21	28	8.5
21	20	30	0.3	19	33	0.0	17	22	0.2
22	21	30	0.0	21	32	0.0	13	31	0.0
23	20	28	1.2	21	39	0.0	17	30	0.0
24	17	29	0.0	16	27	3.8	20	31	0.5
25	18	30	7.0	16	21	0.0	19	31	1.3
26	20	25	7.3	17	29	0.0	23	31	4.6
27	19	30	0.0	18	31	4.6	23	31	0.0
28	19	27	0.0	20	30	0.6	19	32	0.0
29	19	31	0.0				19	32	0.0
30	18	30	0.0				23	34	0.0
31	20	29	0.0				23	33	0.0
Average	19.5	28.9		19.5	31.0		20.2	30.9	
Total			76.1			11.2			127.1

[a] TMin = Daily minimum temperature.
[b] TMax = Daily maximum temperature.
[c] Precip = Precipitation.
[d] M = Mist (< 0.1 ml).

Date	April 1989			May 1989			June 1989		
	TMin[a]	TMax[b]	Precip[c]	TMin	TMax	Precip	TMin	TMax	Precip
1	22	35	0.0	21	34	0.0	26	36	0.0
2	21	34	0.0	21	34	0.0	24	36	4.0
3	22	37	11.2	21	34	0.0	24	36	0.0
4	23	35	00.	21	34	0.0	23	37	0.0
5	21	35	0.0	21	34	0.0	23	37	0.0
6	21	35	0.0	20	36	0.0	24	34	M
7	22	30	7.5	21	36	0.0	23	33	16.0
8	22	33	0.5	20	34	0.0	23	27	20.5
9	22	34	0.0	24	37	0.0	23	30	1.0
10	22	33	0.0	24	38	0.0	23	34	0.0
11	21	33	0.0	23	36	0.0	24	34	0.0
12	21	34	13.5	23	36	0.0	23	35	0.0
13	22	32	0.0	22	37	0.0	24	35	0.0
14	21	34	0.0	22	37	0.0	23	38	0.0
15	20	36	0.7	23	36	0.0	24	36	9.0
16	22	36	0.0	22	35	1.8	23	35	0.0
17	21	35	0.0	23	37	0.0	23	37	0.0
18	16	35	0.0	23	37	0.0	24	36	0.0
19	19	33	4.0	23	36	4.4	24	34	3.0
20	19	33	0.2	24	35	0.0	23	37	0.0
21	21	33	0.8	25	35	0.5	25	32	1.6
22	21	33	2.8	29	30	2.2	25	35	0.2
23	21	32	0.0	24	35	3.4	25	37	0.0
24	18	34	0.0	24	36	0.0	24	36	0.0
25	20	34	0.0	24	38	7.9	25	37	0.0
26	20	33	0.0	25	37	0.1	24	37	0.2
27	24	34	40.0	24	34	0.2	23	33	16.0
28	22	32	0.0	25	39	0.0	23	26	21.0
29	24	35	0.0	26	39	0.0	24	30	0.6
30	22	35	0.0	26	38	0.0	25	33	0.0
31				26	36	0.0			
Average	21.1	33.9		23.2	35.8		23.8	34.4	
Total			81.2			20.5			103.1

[a] TMin = Daily minimum temperature.
[b] TMax = Daily maximum temperature.
[c] Precip = Precipitation.
[d] M = Mist (< 0.1 ml).

	July 1990			August 1990			September 1990		
Date	TMin[a]	TMax[b]	Precip[c]	TMin	TMax	Precip	TMin	TMax	Precip
1	23	35	0.0	23	37	0.0	22	33	17.5
2	22	35	0.0	24	36	0.0	23	29	3.0
3	24	34	1.0	25	35	2.4	23	29	5.0
4	24	35	0.0	24	36	3.0	22	32	24.5
5	25	33	9.0	24	26	60.2	22	31	2.2
6	24	35	4.6	23	28	8.0	22	32	2.4
7	24	34	1.2	22	34	0.0	23	35	0.2
8	23	33	27.5	24	34	6.0	22	34	0.3
9	23	33	0.5	23	30	0.0	24	34	10.0
10	22	35	2.4	22	34	4.0	23	33	0.0
11	22	35	0.4	23	35	1.0	24	36	0.0
12	23	34	0.4	24	36	0.0	24	36	0.0
13	23	34	1.0	24	35	0.0	23	35	0.2
14	23	36	0.0	23	33	0.0	23	35	6.0
15	23	36	4.4	23	35	5.0	22	32	7.5
16	22	33	10.5	23	34	2.2	23	33	1.4
17	23	35	5.8	24	34	0.5	24	34	0.4
18	22	35	1.0	23	36	0.0	24	34	0.0
19	23	33	13.0	22	37	0.0	24	34	1.6
20	22	32	35.0	22	36	0.0	24	34	0.0
21	22	34	0.5	23	36	4.0	23	33	17.5
22	23	34	5.0	23	35	0.0	22	34	0.0
23	24	35	0.0	24	35	0.5	22	35	0.0
24	23	36	0.0	24	35	1.5	22	35	0.0
25	24	36	0.0	23	37	0.0	22	35	135.9
26	23	38	1.0	23	36	5.0	22	34	0.0
27	22	34	0.0	23	35	0.0	23	34	4.4
28	22	36	0.0	24	34	1.0	23	33	3.8
29	23	38	0.0	23	36	0.0	23	30	0.0
30	22	37	0.0	20	36	0.0	22	33	0.0
31	23	36	0.0	21	37	0.0			
Average	23.0	34.8		23.1	34.0		22.9	33.4	
Total			124.2			104.3			243.8

[a] TMin = Daily minimum temperature.
[b] TMax = Daily maximum temperature.
[c] Precip = Precipitation.
[d] M = Mist (< 0.1 ml).

	October 1990			November 1990			December 1990		
Date	TMin[a]	TMax[b]	Precip[c]	TMin	TMax	Precip	TMin	TMax	Precip
1	23	29	42.0	21	30	4.0	22	25	11.5
2	22	34	17.0	21	31	0.0	22	27	10.0
3	24	32	0.3	20	32	0.5	22	29	1.8
4	22	34	8.0	23	30	17.5	22	28	0.0
5	24	33	0.0	19	27	3.0	22	24	17.0
6	23	32	30.0	24	26	15.0	21	26	2.6
7	23	34	0.0	24	31	0.0	21	28	0.5
8	23	33	0.0	20	31	0.0	19	25	0.0
9	23	34	0.0	22	33	0.0	13	24	0.0
10	22	34	3.0	18	28	0.0	12	25	0.0
11	22	33	11.0	17	27	0.0	14	27	0.0
12	24	31	0.0	19	26	5.5	13		
13	19	32	0.0	18	23	27.5			
14	18	33	0.0	18	26	46.0			
15	20	34	0.0	23	28	15.0			
16	21	34	0.0	18	30	18.0			
17	24	32	10.0	23	33	0.0			
18	23	33	0.0	21	27	0.0			
19	19	33	0.0	18	29	0.0			
20	21	33	1.0	17	30	0.0			
21	22	33	0.0	16	29	0.0			
22	23	34	0.0	18	30	0.0			
23	23	34	5.0	17	30	0.0			
24	23	33	0.0	17	30	0.0			
25	24	31	0.0	17	29	0.0			
26	19	29	0.0	16	29	0.0			
27	16	29	0.0	20	31	0.0			
28	18	29	0.0	20	31	3.5			
29	17	31	0.0	23	30	36.0			
30	19	31	1.6	23	27	20.0			
31	20	32	2.0						
Average	21.5	32.4		19.7	29.1		18.6	26.2	
Total			130.9			211.5			43.4

[a] TMin = Daily minimum temperature.
[b] TMax = Daily maximum temperature.
[c] Precip = Precipitation.
[d] M = Mist (< 0.1 ml).

APPENDIX B

MEAN BODY MASS (G), DIET CLASSIFICATION, MEAN POPULATION DENSITY (NUMBER OF INDIVIDUALS/KM^2), AND GAME STATUS FOR SELECTED MAMMALS IN QUINTANA ROO

Taxa[a]	Mean body mass (g)[b]	Diet class[c]	Mean population density[a]	Game status[d]
a) Marsupials				
Caluromys derbianus	1,300	FO	13.4	N
Didelphis marsupialis	1,041	FO	55.3	N
Didelphis virginiana				N
Marmosa canescens				N
Marmosa mexicana				N
Philander opossum	400	IO	62.9	N
b) Primates				
Alouatta pigra	6,500	FH	12.0	N
Ateles geoffroyi	7,500	FH	18.0	N
c) Edentates				
Dasypus novemcinctus	3,544	IO	21.9	N
Tamandua mexicana	4,210	MY	5.2	N
d) Lagomorphs				
Sylvilagus floridanus	1,025	HG	35.0	N
e) Rodents				
Agouti paca	8,227	FG	27.5	G
Coendou mexicanus				N
Dasyprocta punctata	3,600	FG	19.7	G
Orthogeomys hispidus	400			G
Sciurus deppei	225			N
Sciurus yucatanensis	400			N
f) Carnivores				
Bassariscus sumichrasti				N
Conepatus semistriatus	1,700	FO	13.8	N
Eira barbara	3,980	FO	1.0	N
Felis concolor	37,000	CA	0.1	N
Felis pardalis	10,460	CA	0.8	N
Felis wiedii		CA		N

Taxa[a]	Mean body mass (g)[b]	Diet class[c]	Mean population density[a]	Game status[d]
Felis yagouaroundi	5,000	CA	0.5	N
Galictis vittata	2,910	CA	2.4	N
Mustela frenata				N
Nasua nasua	3,880	FO	15.1	G
Panthera onca	68,750	CA	0.1	N
Potos flavus	2,490	FO	24.4	N
Procyon lotor	8,850	FO	10.0	N
Urocyon cinereoargenteus	1,750			N
g) Perissodactyls				
Tapirus bairdii	275,000	FH	0.5	N
h) Artiodactyls				
Tayassu pecari	28,550	FH	4.9	G
Tayassu tajacu	17,520	FH	11.9	G
Mazama americana	26,100	FH	10.5	G
Odocoileus virginianus	40,000	HB	2.8	G

[a] Excludes bats, insectivores, small rodents, marine mammals, and endemic species located on off-shore islands.

[b] Based in part on Navarro L. et al. (1990) and Robinson and Redford (1986, 1989). Additional information obtained from animals collected during this study (see Chapter 3 for additional information about weights of game species).

[c] Diet class (adapted from Eisenberg, 1981): CA = carnivore, FG = frugivore-granivore, FH = frugivore-herbivore, FO = frugivore-omnivore, HB = herbivore-browser, HG = herbivore-grazer, IO = insectivore-omnivore, and MY = myrmecophage.

[d] Game status was based on information provided by Maya hunters at Ejido X-Hazil y Anexos: G = game species and N = nongame species (see Chapter 3 for additional information about how game species were defined).

APPENDIX C
MEAN BODY MASS (G), DIET CLASSIFICATION, MEAN POPULATION DENSITY (NUMBER OF INDIVIDUALS/KM^2), AND GAME STATUS FOR SELECTED BIRDS IN QUINTANA ROO[a]

Taxa[b]	Mean body mass (g)[c]	Diet class[c]	Game status[d]
a) Tinamous			
Crypturellus boucardi	432-485	FG	NG
Crypturellus cinnamomeus	350-500	FG	G
Crypturellus soui		FG	NG
Tinamus major	900-1200	FG	NG
b) Chachalacas, Guans, and Curassows			
Crax rubra	3100-4270	FH	G
Penelope purpurascens	1620-2430	FH	NG
Ortalis vetula	397-527	FH	G
c) Quails			
Odontophorus thoracicus	170-266	IO	NG
d) Turkeys			
Agriocharis ocellatus	2600-3100	FO	G
e) Pigeons and Doves			
Columba flavirostris	241-336	FG	NG
Columba speciosa	254-287	FG	NG
Geotrygon montana	110-145	FG	NG
Leptotila spp.	145-205	FG	NG
Zenaida asiatica	130-196	FG	NG
e) Parakeets and Parrots			
Aratinga astec		FG	NG
Amazona autumnalis		FG	NG

[a] Based in part on Leopold (1972), López Ornat (1990), Paynter (1955a, 1955b), and Terborgh et al., 1990. Additional information obtained from animals collected during this study (see Chapter 3 for additional information about weights of game species).
[b] Potential game taxa only.
[c] Based in part on Terborgh et al. (1990).
[d] Based in part on Leopold (1972, 1977), Paynter (1955a, 1955b), and information obtained from Maya hunters during this study.

APPENDIX D
DATA FORMS USED DURING HUNTER INTERVIEWS. FORM A INCLUDES SPECIFIC QUESTIONS ABOUT THE OUTING (ONE FORM PER OUTING), WHEREAS FORM B INCLUDES QUESTIONS ABOUT THE GAME SPECIES TAKEN (ONE FORM PER PREY ITEM). BOTH FORMS ORIGINALLY APPEARED IN SPANISH

Form A:

JORGENSON AND CO., HUNTER INTERVIEW, Q. ROO, MEXICO, 1989-1990

1. Record number?__________ Field number?__________

2. Interviewer?__________

   1-JPJ, 3-ABdeJ, 7-RUCh, 8-ABX, 9-Other

3. Interviewee?__________

4. Interview date?_____/_____/_____ (month/day/year)

5. Kill date?_____/_____/_____

6. (Question not used)

7. (Question not used)

8. Time hunting outing began (departure from house)?__________

   (0000-2359; 0000 = midnight, 1200 = noon, 1800 = 6 pm)

9. Time of game kill?__________

10. Time hunting outing ended (returned to house)?__________

11. Total duration of hunting outing?__________

12. Hunter group size?__________

13. Group members (names)?__________

14. Number of shotguns in group?__________

15. Number of rifles in group?__________

16. Number of other types of weapons?__________

    (See 32.2-32.20 for dogs)

17. What types of weapons?__________

18. Type of hunting?__________

    1-Tracking/Stalking, 2-Stand/Platform, 3-Trapping, 9-Other

19. If tracking/stalking, distance covered during the hunting outing?________ m

20. Location of the game kill site (direction and distance from the hunter's house or other landmark)?__________

21. If the game kill site is a garden, the name of the garden owner?__________

22. Map coordinates of the game kill site?__________

    Other animals noted during the hunting outing:

23. Species?__________

24. Type of observation?__________

    1-Visual, 2-Sign (feces, tracks, nest, etc.), 3-Sound/Call, 9-Other

25. Number of individuals sighted/observed?__________

26. Vegetation type where animal was sighted/observed?__________

1-Vegetable plot, 2-Garden [2.1-Newly cleared garden, 2.2-Newly planted garden, 2.3-Harvested garden, 2.4-Old garden], 3-Orchard, 4-Early secondary forest, 5-Late secondary forest, 5.1-"Burned" late secondary forest, 5.2-"Partially cleared" late secondary forest, 6-"Low height" late secondary forest, 7-Seasonal wetlands, 9-Other

Result of sighting/observation:

27. Animal shot at?__________

1-Yes, 2-No, 3-Not applicable

28. Firearm/weapon used?__________

10-20 gauge shotgun, 11-16 gauge shotgun, 12-12 gauge shotgun, 20-22 caliber rifle, 21-Other caliber rifle, 30-Trap/Snare, 40-Not applicable, 99-Other

29. Name of hunter?__________

30. Result of sighting/observation?__________

1-Animal hunted/collected/trapped, 2-Animal escaped (no shot), 3-Shot missed the animal, 4-No shot attempted, 5-Wounded, 9-Other

30.1 Total number of shots fired?__________

31. Field number of hunted/collected animal? JPJ-__________

32. If the outing was specifically to hunt, why did the hunter go to this specific site?__________

32.1 Main activity of the outing?__________

1-Hunting, 2-Work in the garden, 3-Tap chicle, 4-Logging, 9-Other

32.2 Did dogs accompany the hunter?__________

1-Yes, 2-No

32.3 How many dogs accompanied the hunter?__________

32.4 Name of dog?__________

32.5 Sex of dog?__________

1-Male, 2-Female, 3-Unknown

32.20 Name of the dog that first located or killed the prey?__________

33. Notes (for example, moon, weather, fresh logging or garden burning, ripe fruits or vegetables):__________

34. Map of the hunting outing and game kill site (note distances, directions, and landmarks):

Form B:

JORGENSON AND CO., ANIMAL COLLECTION, Q. ROO, MEXICO, 1989-1990

1. Record number?__________

2. Field number? JPJ-__________

   Date (month/date/year)

3. Kill date?_____/_____/_____

4. Interview date?_____/_____/_____

5. Hunter/collector?__________

6. (Question not used)

7. Scientific name of animal?__________

8. Common name in Maya/Spanish?__________

9. Country? Mexico

10. State? Quintana Roo

11. Municipio?__________

    1-Felipe Carrillo Puerto, 9-Other

12. Name of the general locality?__________

    1-Rancho Las Palmas, 2-Ejido X-Hazil y Anexos, 9-Other

13. Location of the game kill site (direction and distance from the hunter's house or other landmark)?__________

14. Latitude?_____°_____' North

15. Longitude?_____°_____'West

16. Elevation?__________ m

17. Map coordinates of the game kill site?__________

18. Vegetation type where animal was sighted/observed?__________

    1-Vegetable plot, 2-Garden [2.1-Newly cleared garden, 2.2-Newly planted garden, 2.3-Harvested garden, 2.4-Old garden], 3-Orchard, 4-Early secondary forest, 5-Late secondary forest, 5.1-"Burned" late secondary forest, 5.2-"Partially cleared" late secondary forest, 6-"Low height" late secondary forest, 7-Seasonal wetlands, 9-Other

19. Age of the game kill site?__________ y

19.1 Name in Maya for this type of vegetation?__________

20. Weight/measurements of the animal measured (1) or estimated (2)?__________

21. Total length of animal (from nose/bill to tip of tail)?________ mm

21.1 Length of the folded wing (birds only)?__________ mm

22. Tail length of animal?__________ mm

23. Hind foot length of animal (tarsus for birds; right/left)?_____ mm

24. Ear length of animal (bill for birds; right/left)?__________ mm

25. Total weight of animal?__________ g

25.1 Net weight of animal (without guts etc.)?__________ g

26. Total weight of animal estimated by the hunter?__________ g

27. Sex of animal?__________

1-Male, 2-Female, 3-Unknown

28. Reproductive condition?__________

Females: 1-Lactating, 2-With embryos/eggs, 3-With a litter, 4-Not lactating/no embryos/no litter, 5-Unknown

Males (condition of the testes): 6-Abdominal, 7-Scrotal, 8-Unknown

Sex unknown: 9-Unknown

29. Age of the animal estimated by the hunter?__________

1-Adult, 2-Subadult/young, 3-Newborn, 4-Unknown

29.1 Behavior of the animal at the time when hunted/collected?__________

1-Resting, 2-Eating, 3-Walking/running/flying, 9-Other

30. Time of game kill?__________

(0000-2359; 0000 = midnight, 1200 = noon, 1800 = 6 pm)

30.1 Weights/measurements from a dead (1) or live (2) animal?__________

	Sample Collected		Form Preparation		Number Items	
30.2	Complete animal?	_____	30.3	_____	30.31	_____
30.4	Feathers?	_____	30.5	_____	30.51	_____
30.6	Feet?	_____	30.7	_____	30.71	_____
31.	Skull?	_____	32.	_____	32.1	_____
33.	Skin?	_____	34.	_____	34.1	_____
35.	External parasites?	_____	36.	_____	36.1	_____
37.	Internal parasites?	_____	38.	_____	38.1	_____
39.	Internal organs?	_____	40.	_____	40.1	_____
41.	Stomach contents?	_____	42.	_____	42.1	_____

Form of preparation: 1-Dry, 2-Salt, 3-Corn meal, 4-15% Formalin, 5-70% Ethyl alcohol, 9-Other

43. Total volume of the stomach contents (incl. 43.1 & 43.3)?______ ml

For birds (43.1-43.4):

43.1 Subtotal in gizzard?__________ ml

43.2 Number of containers?__________

43.3 Subtotal in mouth/esophagus/crop?__________ ml

43.4 Number of containers?_________

44. Preliminary identification of the stomach contents, according to the hunter?_________

45. Type of outing?_________

1-Active hunting/fishing/trapping, 2-Opportunistic hunting/fishing/trapping, 3-Road kill, 9-Other

46. Purpose of the collection?_________

1-Personal consumption (including limited sale or exchange), 2-Personal pet, 3-Pet to be sold commercially, 4-Kill a noxious animal (not for consumption), 5-Scientific collection, 9-Other

47. Interviewer?_________.

1-JPJ, 3-ABdeJ, 7-RUCh, 8-ABX, 9-Other

48. Notes:

APPENDIX E

GAME HARVEST INVENTORIES FOR THE SEVEN MAIN HUNTERS (315 PREY WITH WEIGHTS) AT X-HAZIL SUR COMPARED WITH THE GAME TAKEN BY THE REMAINING 79 HUNTERS (261 PREY WITH WEIGHTS) THAT REPORTED TAKING GAME (ARRANGED BY GRAND TOTAL NUMBER OF PREY ITEMS)

Game Species	Hunter number & age (y) # 35 (37)	# 6 (35)	# 1 (17)	# 18 (17)	# 9 (21)	# 62 (23)	# 98 (16)	All other hunters (n = 79)	n
a) Mammals									
Pocket gopher			6	2	3	8		34	53
Paca	10	5	6		1			25	47
Agouti	4	1	8	1	1	1		19	35
Coati	58	29	13	6		2	1	58	167
White-lipped peccary		3							
Collared peccary	1	7	4			1	1	26	40
Brocket deer		1	1					14	16
White-tailed deer		4		1				19	24
Total mammals[a]	73	50	38	10	5	12	2	195	385
b) Birds									
Thicket tinamou		1	1	2	1	2	1	5	13
Great curassow		3			1		1	8	13
Plain chachalaca	12	7	5	28	24	13	23	55	167
Ocellated turkey						1		5	6
Total birds[a]	12	11	6	30	26	16	25	73	199
Grand total[a]	85	61	44	40	31	28	27	268	584
Total weight (kg)[b]	274.5	475.5	165.5	64.1	24.3	45.0	35.8	1615.5	2700.1
Mean prey weight (kg)[b]	3.2	7.8	3.8	1.6	0.8	1.7	1.3	6.2	4.7
SE[b]	0.28	1.42	0.68	0.61	0.25	0.75	0.74	0.60	0.33
n[b]	85	61	44	40	31	27	27	261	576

[a] Includes specimens with and without weight measurements.
[b] Includes only specimens with weight measurements.

APPENDIX F
CATALOGUE OF GAME AND NONGAME ANIMALS COLLECTED AT EJIDO X-HAZIL Y ANEXOS DURING 1989-1990, INCLUDING DONATIONS BY LOCAL RESIDENTS, ANIMALS FOUND ALONG THE ROAD, AND GAME TAKEN BY HUNTERS

Scientific Name	Common Name	Quantity
A) Mammals		
Didelphis spp.	Opossum[a]	27
Chiroptera (8 spp.)	Bats	18
Ateles geoffroyi	Spider monkey	1
Tamandua mexicana	Tamandua	2
Dasypus novemcinctus	Armadillo	8
Sciurus deppei	Squirrel[ab]	6
Sciurus yucatanensis	Squirrel[ab]	4
Sciurus sp.	Squirrel[ab]	3
Orthogeomys hispidus	Pocket gopher[ab]	52
Agouti paca	Paca[b]	47
Dasyprocta punctata	Agouti[b]	35
Urocyon cinereoargenteus	Grey fox	2
Procyon lotor	Raccoon	4
Nasua nasua	Coatimundi[b]	167
Potos flavus	Kinkajou	4
Eira barbara	Tayra	1
Conepatus semistriatus	Skunk	1
Felis concolor	Puma	1
Felis onca	Jaguar[b]	1
Felis pardalis	Ocelot[b]	4
Felis wiedii	Margay[b]	6
Felis yagouaroundi	Yagouaroundi	1
Tayassu pecari	White-lipped peccary[b]	3
Tayassu tajacu	Collared peccary[b]	40
Odocoileus virginianus	White-tailed deer[b]	24
Mazama americana	Brocket deer[b]	16
Subtotal Mammals		478

Scientific Name	Common Name	Quantity
B) Birds		
Crypturellus cinnamomeus	Thicket tinamou	13
Buteo nitidus	Gray hawk	1
Ortalis vetula	Plain chachalaca[ab]	168
Crax rubra	Great curassow[b]	13
Agriocharis ocellata	Ocellated turkey[b]	6
Columba flavirostris	Red-billed pigeon[ab]	22
Columba speciosa	Scaled pigeon[ab]	1
Zenaida asiatica	White-winged dove[ab]	1
Leptotila verreauxi	White-tipped dove[ab]	1
Aratinga astec	Aztec parakeet[a]	2
Amazona albifrons	White-fronted parrot[a]	7
Piaya cayana	Squirrel cuckoo	1
Chordeiles minor	Common nighthawk	1
Ciccaba virgata	Mottled owl	1
Ramphastos sulfuratus	Keel-billed toucan	2
Campephilus guatemalensis	Pale-billed woodpecker	1
Subtotal Birds		241
C) Fish		
Cichlasoma urophthalmus	Unidentified	8
Subtotal Fish		8
D) Reptiles		
Bothrops sp.	Fer de lance	1
Micrurus sp.	Coral snake	1
Unidentified	Unidentified lizard	1
Subtotal Reptiles		3
Grand total		730

[a] Animal for which data were not collected during the entire study period.
[b] Game and nongame animals taken at the village of X-Hazil Sur, Quintana Roo, Mexico, during April 1989-November 1990.

APPENDIX G
PERCENT FREQUENCY OF THE GAME KILL SITES IN THE FOUR MAIN VEGETATION TYPES FOR THE GAME TAKEN BY HUNTERS AT X-HAZIL SUR

	Percentage of game kill sites by vegetation type				
Game species	Plots & Gardens (6.1%)[a]	Early Secondary Forest (5.2%)	Late Secondary Forest (88.5%)	Other (0.2%)	n
a) Mammals					
Pocket gopher	41.5	52.8	5.7	0.0	53
Paca	34.0	31.9	34.0	0.0	47
Agouti	48.6	20.0	31.4	0.0	35
Coati	46.7	8.4	44.9	0.0	167
White-lipped peccary	0.0	0.0	100.0	0.0	3
Collared peccary	25.0	17.5	57.5	0.0	40
Brocket deer	37.5	12.5	50.0	0.0	16
White-tailed deer	62.5	20.8	12.5	4.2	26
% Mammals combined	42.6	20.3	36.9	0.3	385
b) Birds					
Thicket tinamou	0.0	23.1	76.9	0.0	13
Great curassow	7.7	0.0	92.3	0.0	13
Plain chachalaca	7.2	86.8	6.0	0.0	167
Ocellated turkey	50.0	16.7	33.3	0.0	6
% Birds combined	8.0	74.9	17.1	0.0	199
% All game species combined	30.8	38.9	30.1	0.2	584

[a] Values in ( ) indicate the percentage of the study area in each vegetation type. Total area = 552.95 km^2.

APPENDIX H
SUMMARY OF CENSUS RESULTS AND CHARACTERISTICS OF 12 TRANSECTS IN THREE SUCCESSIONAL STAGES OF FOREST

Transect number	Transect length (m)	Transect succes-sional stage[a]	Number of censuses		Total duration censuses (h)	Average census walking rate (km/h)	Number of sightings	
			Sunrise	Sunset			Mammals	Birds
1[b]	1600	LSF w/o G	3	3	9.42	1.02	3	1
2	1960	LSF w/o G	5	6	21.20	1.02	14	9
3	2000	LSF w/o G	5	5	19.23	1.04	14	2
4	2000	LSF w/o G	5	5	20.33	0.98	8	5
5	2000	C/ESF	5	5	20.93	0.96	11	14
6	2000	LSF w/ G	5	6	22.42	0.98	12	1
7	2000	LSF w/ G	5	6	23.00	0.96	33	0
8	2000	LSF w/ G	5	6	21.97	1.00	15	8
9	2000	C/ESF	5	6	24.23	0.91	7	13
10	2000	C/ESF	5	5	20.53	0.97	6	16
11	2130	C/ESF	5	5	20.75	1.03	9	13
12	2000	LSF w/o G	5	5	20.25	0.99	18	8
Total			58	63	244.27		150	90

[a] Forest successional stages: LSF w/o G = Late Secondary Forest without Gardens (41 censuses; total distance censused = 81.56 km); LSF w/ G = Late Secondary Forest with Gardens (39 censuses; total distance censused = 75.60 km); C/ESF = Combined/Early Secondary Forest (41 censuses; total distance censused = 83.30 km).

[b] Censuses along Transect # 1 were discontinued after six censuses due to problems with a local resident.

APPENDIX I
CENSUS DATA FORM

JORGENSON AND CO., ANIMAL CENSUS DATA FORM

1. Date (month/day/year)? ____/____/____

2. Census number?________

3. Transect number (1-12)?________

4. Transect type? ________

5. Transect length? ________

6. Direction of census? ________

   1--West to east 2--East to west

7. Principal observer (data collector)? ________

   1-JPJ, 2-AMV, 3-ABdeJ, 4-________, 5-_______

8. Guide/field assistant? _______

   1-JPA, 2-RUCh, 3-JHBX, 4-ABdeJ, 5-JPJ, 6-DSCh, 8-GGP, 9 Other________

9. Time census ended?________h 12. Time of return? ______h

10. Time census started? _______h 13. Time of departure? ______h

11. Duration of census? _______h:m 14. Total time spent? ______h:m

Weather conditions at the beginning of the census:

15. Temperature? ________

16. Wind? ________

   1--none/little, 2--moderate, 3--strong (difficult to hear animal noises)

17. Direction of wind (0°-360°)?________

18. Sky? ________ (1--clear, 2--moderately cloudy, 3--cloudy

19. Rain during census? ________ (1--none, 2--light/moderate, 3--strong)

Condition of the moon during census:

20. Phase? ________ [0-14 (days in the sky), 0=new moon and 14=full moon]

21. Brightness? ________ (1--none/little, 2--moderate, 3--very bright)

22. If transect originates at a garden, condition of the garden? _______

   2--*milpa* (*kol*) [2.1--new clearing (*tumbem kol*), 2.1--planting (*pa'a kal*), 2.3--post harvest (*sin ho chik*), 2.4--fallow (*sa ka*), 4--early secondary forest (cleared) (*hub che*), 5--late secondary forest (not cleared) (*sak al che*), 9--other________

23. Number (quantity) of animals observed?________

23.1. Record number of observed animals______________________________

Speed of census:

   24. m/min: ________m/________min=________m/min

   24.1. m/h: ________h/min x 60 =________m/h

25. Number (sighting number) of animal observed?________

26. Transect number (li)________

26.1. Perpendicular distance from the transect to the animal observed? (xi)?________

27. Distance between observer and animal (ri)?_________m

28. Angle between observer and animal (oi, $0 < x < 180$)? ________

29. Direction of the animal? _______

30. Direction of transect? _______

31. Time animal was observed? ________h

32. Position of observation of animal within the transect ($0 < x < 2130$ m)?______

33. Type of vegetation where animal was observed? ________

1--vegetable garden (*kan che*), 2--*milpa (kol)* [2.1--new clearing (*tumbem kol*), 2.2--Planting (*pa'akal*), 2.3.-post harvest, (*sin ho chik*), 2.4-fallow (*sa ka*), 3-family garden (-), 4-early secondary forest (*hub che*), 5--late secondary forest (*no kux kax, ka na kax*), 5.1--burned (*to ka che*), 5.2--low late secondary forest [somewhat cleared] (*ka bu kax*), 6--low late secondary forest [not cleared] (*sak al che*), 7--wetland (*hak kan*), 9--other ________

34. Scientific name of animal observed? ________

35. Common Spanish/Maya name of animal observed? _________

36. Sex of animal observed? ________ (1--male, 2--female, 3--unknown)

37. Age of animal observed? ________ (1--adult, 2--subadult/young, 3--new born/offspring, 9--other_______

38. Behavior of animal observed during observation?__________

(1--resting, 2--eating, 3--walking/running/flying, 9--other________

If eating:

39. Scientific name of plant? ________

40. Spanish/Maya common name of plant? ________

41. Height of animal observed (0 = on ground)? ________m

If not on the ground:

42. Scientific name of plant where animal was observed? ________

43. Spanish/Maya common name? ________

44. Type of observation (initial factor that attracted observer's attention)? _______

(1--visual, 2--signs (feces, tracks, nest, etc.)

Notes:____

APPENDIX J

MEAN SIGHTING DISTANCES OF WILDLIFE (M), SUMMARIZED BY SPECIES, GROUPS, AND GAME AND NONGAME BIRDS AND MAMMALS CENSUSED ALONG 12 TRANSECTS IN THREE SUCCESSIONAL STAGES OF FOREST AT EJIDO X-HAZIL Y ANEXOS, QUINTANA ROO, MEXICO, DURING 1990 (D.F. = 2 THROUGHOUT)

Taxa[a]	Successional stages: Late Secondary Forest without Gardens $\bar{x}$[b]	SE	Late Secondary Forest with Gardens $\bar{x}$	SE	Combined/ Early Secondary Forest $\bar{x}$	SE	χ^2 approximation	P
a) Species								
Squirrels	13.1	(1.2)	11.9	(1.3)	16.1	(3.5)	0.2866	0.8665
Coati*[c]	12.0	(6.0)	25.6	(2.9)	---	(---)	2.6305	0.1048
Kinkajou	17.5	(2.4)	14.5	(1.9)	11.2	(1.2)	1.5109	0.4698
Plain chachalaca*	11.3	(2.5)	13.9	(3.1)	12.7	(0.8)	1.4101	0.4941
b) Groups								
Marsupials & Edentates	8.8	(1.6)	10.8	(2.9)	10.6	(3.8)	0.1079	0.9475
Rodents	13.2	(1.0)	14.7	(1.4)	15.8	(2.8)	0.2731	0.8723
Carnivores	17.2	(2.1)	20.2	(2.0)	16.1	(3.0)	1.3694	0.5042
Artiodactyls	29.1	(10.8)	15.6	(11.6)	17.2	(2.5)	1.3849	0.5004
Birds	14.2	(2.8)	13.2	(2.2)	12.8	(0.7)	0.4826	0.7856
c) Game versus nongame species[c]								
Game mammals	16.0	(3.0)	22.0	(2.0)	16.2	(1.6)	3.3406	0.1882
Nongame mammals	14.5	(1.2)	12.6	(1.1)	14.8	(2.1)	1.3309	0.5140
Game birds	11.0	(1.9)	12.8	(2.5)	13.2	(0.8)	1.9881	0.3701
Nongame birds	36.4	(13.6)	16.8	(---)	10.5	(1.4)	3.5857	0.1665

[a] See Appendix L for common and scientific names.

[b] $\bar{x}$ = The constant 10,000 multiplied by the average sighting distance for the four replicate transects.

[c] * = Game species. See Chapter 3 for additional information about game species.

APPENDIX K
NUMBER OF SIGHTINGS/100 KM AND TOTAL NUMBER OF SIGHTINGS (N), SUMMARIZED BY SPECIES, GROUPS, AND GAME AND NONGAME BIRDS AND MAMMALS

Taxa[a]	Successional stages: Late Secondary Forest without Gardens	Late Secondary Forest with Gardens	Combined/ Early Secondary Forest	n
MAMMALS				
a) Marsupials & Edentates				
Opossum	2.5 (2)[b]	2.6 (2)	0.0 (0)	4
Tamandua	0.0 (0)	0.0 (0)	1.2 (1)	1
Nine-banded armadillo	2.5 (2)	7.9 (6)	6.0 (5)	13
Subtotal	4.9 (4)	10.6 (8)	7.2 (6)	18
b) Rodents				
Squirrels[c]	27.0 (22)	17.2 (13)	14.4 (12)	47
Pocket gopher*[d]	0.0 (0)	0.0 (0)	1.2 (1)	1
Paca*	2.5 (2)	7.9 (6)	0.0 (0)	8
Agouti*	6.1 (5)	6.6 (5)	2.4 (2)	12
Subtotal	35.6 (29)	31.7 (24)	18.0 (15)	68
c) Carnivores				
Gray fox	0.0 (0)	1.3 (1)	3.6 (3)	4
Coati*	2.5 (2)	19.8 (15)	0.0 (0)	17
Kinkajou	19.6 (16)	15.9 (12)	3.6 (3)	31
Mustelids[e]	1.2 (1)	1.3 (1)	1.2 (1)	3
Subtotal	23.3 (19)	38.4 (29)	8.4 (7)	55
d) Artiodactyls				
Collared peccary*	0.0 (0)	0.0 (0)	2.4 (2)[f]	2
Brocket deer*	1.2 (1)	1.3 (1)	2.4 (2)	4
White-tailed deer*	1.2 (1)	1.3 (1)	1.2 (1)	3
Subtotal	2.5 (2)	2.6 (2)	6.0 (5)	9
Total mammals	66.2 (54)	83.3 (63)	39.6 (33)	150

Taxa[a]	Successional stages: Late Secondary Forest without Gardens	Late Secondary Forest with Gardens	Combined/ Early Secondary Forest	n
BIRDS				
Tinamou*[g]	6.1 (5)	4.0 (3)	4.8 (4)	12
Plain chachalaca*	19.6 (16)	6.6 (5)	51.6 (43)	64
Ocellated turkey*	0.0 (0)	1.3 (1)	1.2 (1)	2
Columbids[h]	3.7 (3)	0.0 (0)	9.6 (8)	11
White-fronted parrot	0.0 (0)	1.3 (1)	0.0 (0)	1
Total birds	29.4 (24)	13.2 (10)	67.2 (56)	90
GAME VERSUS NONGAME SPECIES[d]				
Game mammals	13.5 (11)	37.0 (28)	9.6 (8)	47
Nongame mammals	52.7 (43)	46.3 (35)	30.0 (25)	103
Game birds	25.7 (21)	11.9 (9)	57.6 (48)	78
Nongame birds	3.7 (3)	1.3 (1)	9.6 (8)	12
Total	(78)	(73)	(89)	240

[a] See Appendix L for common and scientific names.
[b] (n) = Number of sightings.
[c] Composed of *Sciurus deppei*, *S. yucatanensis*, and an unidentified squirrel (not a new taxon).
[d] * = Game species. See Chapter 3 for additional information about game species.
[e] Tayra and skunk.
[f] One sighting of a single individual and one sighting of nine individuals in a single group.
[g] Slaty-breasted and thicket tinamou.
[h] Scaled pigeon and white-tipped dove.

APPENDIX L
COMMON AND SCIENTIFIC NAMES OF BIRDS AND MAMMALS SIGHTED AT EJIDO X-HAZIL Y ANEXOS DURING 121 CENSUSES IN 1990

Scientific name[a]	Family	English common name
a) Mammals		
Didelphis spp.	Didelphidae	Opossum
Tamandua mexicana	Myrmecophagidae	Tamandua
Dasypus novemcinctus	Dasypodidae	Nine-banded armadillo
Sciurus deppei	Sciuridae	Squirrel
Sciurus yucatanensis	Sciuridae	Squirrel
*Orthogeomys hispidus**[b]	Geomyidae	Pocket gopher
*Agouti paca**	Agoutidae	Paca
*Dasyprocta punctata**	Dasyproctidae	Agouti
Urocyon cinereoargenteus	Canidae	Gray fox
*Nasua nasua**	Procyonidae	Coati
Potos flavus	Procyonidae	Kinkajou
Eira barbara	Mustelidae	Tayra
Conepatus semistriatus	Mustelidae	Skunk
*Tayassu tajacu**	Tayassuidae	Collared peccary
*Mazama americana**	Cervidae	Brocket deer
*Odocoileus virginianus**	Cervidae	White-tailed deer
b) Birds		
Crypturellus boucardi	Tinamidae	Slaty-breasted tinamou
*Crypturellus cinnamomeus**	Tinamidae	Thicket tinamou
*Ortalis vetula**	Cracidae	Plain chachalaca
*Agriocharis ocellata**	Meleagrididae	Ocellated turkey
Columba speciosa	Columbidae	Scaled pigeon
Leptotila verreauxi	Columbidae	White-tipped dove
Amazona albifrons	Psittacidae	White-fronted parrot

[a] Primary sources for scientific names: Leopold (1977) and Peterson and Chalif (1973).
[b] * = Game species. See Chapter 3 for additional information about game species.

APPENDIX M
DATA FORM: STOMACH CONTENTS ANALYSIS

STOMACH CONTENTS ANALYSIS
JORGENSON AND COMPANY: 1990

Field number?	Maya common name of animal?
Date of collection (month/date/year)?	Scientific name of animal?

Item no.	Maya common name	Item scientific name	Plant/animal part consumed (ml)				
			Fruits & seeds	Leaves	Animal matter[a]	Other[b]	Total
1							
2							
3							
4							
5							
6							
7							
8							
9							
Total volume (ml)							
Total volume of the original sample (ml)							

Original identification by?	Date of identification (month/date/year)? ____/____/____
Confirmation by?	Date of confirmation (month/date/year)? ____/____/____

[a] Animal matter includes hair, snail shells, and insect antennae.
[b] Other includes tubers, roots, stems, plastic, rocks, and soil.

APPENDIX N
PERCENT OCCURRENCE (% OCC.) AND VOLUME (% VOL.) OF PACA FOOD ITEMS BASED ON AN ANALYSIS OF THE CONTENTS OF 36 STOMACHS (TOTAL VOLUME ANALYZED = 1886.5 ML) COLLECTED FROM PACAS TAKEN BY MAYA HUNTERS AT X-HAZIL SUR, QUINTANA ROO, MEXICO, DURING JUNE 1989-OCTOBER 1990

Food item[a]	Family	Local names[b]	% Occ.	% Vol.
Manilkara zapota (L.) v. Royen	Sapotaceae	*Ya* *Chicozapote*	47.2	26.6
Zea mays L.*	Gramineae	*Nall* *Maiz* Corn	25.0	15.4
Dendropanax arboreus (L.) Dcne. & Planch.	Araliaceae	*Sac chacá* ---	22.2	15.3
Cucurbita moschata Duch.*	Cucurbitaceae	*Ku'um* *Calabaza* Squash	22.2	14.9
Byrsonima crassifolia (L.) HBK.	Malpighiaceae	*Chi* *Nance dulce*	22.2	1.6
Unidentified plant	---	--- ---	19.4	< 0.0
Coccoloba acapulcensis Standl.	Polygonaceae	*To'yub* ---	16.7	8.6
Misc. mammal tissue (skin & hair)	Class Mammalia	--- ---	16.7	< 0.0
Cissus sicyoides L.	Vitaceae	*Tacaní* ---	11.1	8.4
Pithecellobium sp.	Leguminosae	*Choc che* ---	11.1	0.6
Misc. mammal tissue (feces)	Class Mammalia	--- ---	11.1	0.1
Diospyros sp.	Ebenaceae	*Silil &* *Uh chu che* ---	8.3	0.1
Brosimum alicastrum Swartz	Moraceae	*Ox* *Ramón*	8.3	< 0.0
Psychotria sp.	Rubiaceae	--- *Kanan verde*	8.3	< 0.0
Dipholis salicifolia (L.) A. DC.	Sapotaceae	*Ik che &* *Tzi tzi yah* ---	5.6	0.3
Unidentified plant	---	*Chit ku'uk* ---	5.6	0.1
Cydista potosina (Schum. & Loes.) Loes.	Bignoniaceae	*E ki xil* ---	5.6	< 0.0

Food item[a]	Family	Local names[b]	% Occ.	% Vol.
Unidentified insect	Order Orthoptera	--- *Grillo*	5.6	< 0.0
Manihot esculenta Crantz.*	Euphorbiaceae	*Dzi'im* *Yuca* *Yuca*	2.8	2.9
Ipomoea batatas (L.) Lam.*	Convolvulaceae	*Is* *Camote*	2.8	2.7
Byrsonima bucidaefolia Standl.	Malpighiaceae	*Sac paa* *Nance agrio*	2.8	2.4
Pouteria unilocularis (Donn. Smith) Baehni	Sapotaceae	*Chac yá* ---	2.8	0.1
Unidentified terrestrial worm	Class Oligochaeta	*Lu kum* *Lombriz*	2.8	0.1
Sabal yapa C. Wright ex Beccari	Palmae	*Bom & Xa'an* *Huano*	2.8	< 0.0
Coccoloba sp.	Polygonaceae	*Chich bob* ---	2.8	< 0.0
Unidentified plant	Euphorbiaceae	*Naap che* ---	2.8	< 0.0
Unidentified slug	Class Gastropoda	--- *Gusano*	2.8	< 0.0
Unidentified plant	Unidentified	*Zu uc* *Zacate*[c]	2.8	< 0.0

[a] * = Crop species.

[b] Maya names precede Spanish names. English names included for crops only.

[c] *Zu uc/Zacate* (unidentified species) apparently is not the same as *Ak nom/Zacate* [Scleria lithospermum (L.) Swartz].

APPENDIX O

PERCENT OCCURRENCE (% OCC.) AND VOLUME (% VOL.) OF AGOUTI FOOD ITEMS BASED ON AN ANALYSIS OF THE CONTENTS OF 26 STOMACHS (TOTAL VOLUME ANALYZED = 1167.5 ML)

Food item[a]	Family	Local names[b]	% Occ.	% Vol.
Manilkara zapota (L.) v. Royen	Sapotaceae	*Ya* *Chicozapote*	38.5	8.7
Byrsonima crassifolia (L.) HBK.	Malpighiaceae	*Chi* *Nance dulce*	30.8	10.2
Zea mays L.*	Gramineae	*Nall* *Maiz* Corn	23.1	25.5
Ipomoea batatas (L.) Lam.*	Convolvulaceae	*Is* *Camote* Sweet potato	15.4	20.2
Cucurbita moschata Duch.*	Cucurbitaceae	*Ku um* *Calabaza* Squash	15.4	13.6
Brosimum alicastrum Swartz	Moraceae	*Ox* *Ramón*	11.5	< 0.0
Leguminosae[c]	Leguminosae	*Chok che* ---	7.7	8.7
Coccoloba sp.	Polygonaceae	*Chich bob* ---	7.7	3.9
Diospyros sp.	Ebenaceae	*Uh chu che* ---	7.7	0.3
Misc. mammal tissue (skin & hair)	Class Mammalia	--- ---	7.7	< 0.0
Unidentified plant	---	--- ---	7.7	< 0.0
Sabal yapa C. Wright ex Beccari	Palmae	*Bom & Xa'an* *Huano*	7.7	< 0.0
Celtis iguanaea (Jacq.) Sarg.	Ulmaceae	*Chich mu uk* ---	3.8	4.3
Byrsonima bucidaefolia Standl.	Malpighiaceae	*Sac paa* *Nance agrio*	3.8	2.8
Passiflora sp.	Passifloraceae	*Ton ton tzimini* ---	3.8	1.4
Piper auritum HBK.	Piperaceae	*Ma ku lam* ---	3.8	0.3
Unidentified slug	Class Gastropoda	--- *Gusano*	3.8	0.1

Food item[a]	Family	Local names[b]	% Occ.	% Vol.
Scleria lithosperma (L.) Swartz*[d]	Cyperaceae	*Ak nom* *Zacate* ---	3.8	< 0.0
Coccoloba acapulcensis Standl.	Polygonaceae	*To'yub* ---	3.8	< 0.0
Nectandra sanguinea Rottb.	Lauraceae	*Ho choc* ---	3.8	< 0.0
Dendropanax arboreus (L.) Dcne. & Planch.	Araliaceae	*Sac chacá* ---	3.8	< 0.0

[a] * = Crop species.
[b] Maya names precede Spanish names. English names included for crops only.
[c] Either Caesalpinia sp. or Pithecellobium sp.
[d] *Ak nom/Zacate* apparently is not the same as *Zu uc/Zacate* (unidentified species).

APPENDIX P

PERCENT OCCURRENCE (% OCC.) AND VOLUME (% VOL.) OF COATI FOOD ITEMS BASED ON AN ANALYSIS OF THE CONTENTS OF 129 STOMACHS (TOTAL VOLUME ANALYZED = 4678.5 ML)

Food item[a]	Family	Local names[b]	% Occ.	% Vol.
Unidentified slug	Class Gastropoda	--- *Gusano*	50.4	3.8
Unidentified insect	Order Orthoptera	--- *Grillo*	44.2	1.1
Zea mays L.*	Gramineae	*Nall* *Maiz* Corn	40.3	53.5
Manilkara zapota (L.) v. Royen	Sapotaceae	*Ya* *Chicozapote*	28.7	19.0
Unidentified snail	Class Gastropoda	--- *Caracol*	20.2	< 0.0
Vitex gaumeri Greenm.	Verbenaceae	*Yaxnic* ---	14.0	4.7
Coccoloba acapulcensis Standl.	Polygonaceae	*To'yub* ---	9.3	4.0
Brosimum alicastrum Swartz	Moraceae	*Ox* *Ramón*	7.8	5.8
Unidentified slug	Class Gastropoda	*No kol* *Gusano*	7.0	0.5
Unidentified terrestrial worm	Class Oligochaeta	*Lu kum* *Lombriz*	7.0	0.1
Unidentified insect	Class Orthoptera	*Mas* *Grillo*	6.2	0.2
Unidentified plant	Unidentified	--- ---	6.2	< 0.0
Unidentified insect	Class Orthoptera	*Kon choch* *Grillo*	5.4	0.4
Unidentified plant	Unidentified	*Chit ku'uk* ---	5.4	< 0.0
Misc. mammal tissue (skin & hair)	Class Mammalia	--- ---	4.7	1.6
Unidentified insect	Class Orthoptera	*Xo* *Cucaracha*	3.9	0.3
Pouteria unilocularis (Donn. Smith.) Baehni	Sapotaceae	*Chak yá* ---	3.1	1.0
Byrsonima bucidaefolia Standl.	Malpighiaceae	*Sac paa* *Nance agrio*	3.1	0.4

Food item[a]	Family	Local names[b]	% Occ.	% Vol.
Unidentified insects (various)	Class Orthoptera	*Kuklin (?)* ---	3.1	0.1
Unidentified plant	Unidentified	--- *Hierba mora*	2.3	0.7
Unidentified reptile	Class Reptilia	--- *Largartillo*	2.3	0.1
Dipholis salicifolia (L.) A. DC.	Sapotaceae	*Ik che &* *Tzi tzi yah* ---	1.6	0.8
Coccoloba sp.	Polygonaceae	*Chich bob* ---	1.6	0.4
Unidentified plant	Unidentified	*Chico loro*	1.6	0.2
Unidentified reptile	Class Reptilia	*Kan* *Culebra*	1.6	0.2
Sabal yapa C. Wright ex Beccari	Palmae	*Bom & Xa'an* *Huano*	1.6	0.1
Unidentified mushroom	Class Basidiomycetes	--- *Hongo*	1.6	0.1
Unidentified insect	Class Odonata	*Turis* *Libelula*	1.6	< 0.0
Celtis iguanaea (Jacq.) Sarg.	Ulmaceae	*Chich mu uk* ---	1.6	< 0.0
Lysiloma latisiliqua (L.) Benth.	Leguminosae	*Tzalam*	1.6	< 0.0
Leguminosae[c]	Leguminosae	*Chok che* ---	1.6	< 0.0
Diospyros sp.	Ebenaceae	*Silil &* *Uh chu che* ---	0.8	0.8
Unidentified tarantula	Class Arachnoidea	--- *Tarantula*	0.8	< 0.0
Unidentified amphibian	Class Amphibia	--- *Rana/Sapo*	0.8	< 0.0
Carica papaya L.	Cariacaceae	*Pu chich & Puut* ---	0.8	< 0.0
Dendropanax arboreus (L.) Dcne. & Planch.	Araliaceae	*Sac chaca* ---	0.8	< 0.0

Food item[a]	Family	Local names[b]	% Occ.	% Vol.
Unidentified plant	Unidentified	*Can pe tzu* ---	0.8	< 0.0
Dalbergia glabra (Miller) Standl.	Leguminosae	*Muk* ---	0.8	< 0.0
Byrsonima crassifolia (L.) HBK.	Malpighiaceae	*Chi* *Nance dulce*	0.8	< 0.0
Metopium brownei (Jacq.) Urban	Anacardiaceae	*Chechem* ---	0.8	< 0.0
Unidentified plant	Sapindaceae	*Tzool* ---	0.8	< 0.0
Cydista potosina (Schum. & Loes.) Loes.	Bignoniaceae	*E ki xil* ---	0.8	< 0.0
Ficus sp.	Moraceae	*Ha huay &* *Sac ha huay* ---	0.8	< 0.0
Acacia glomerosa Benth.	Leguminosae	*Ju pich* ---	0.8	< 0.0
Unidentified scorpion	Class Arachnoidea	--- *Alacran*	0.8	< 0.0
Unidentified fly	Order Diptera	--- *Tabano*	0.8	< 0.0
Unidentified slug	Order Gastropoda	*Piix* *Gusano*	0.8	< 0.0
Unidentified bird	Class Aves	--- *Pájaro*	0.8	< 0.0
Plastic, Rocks, & Soil	---	---	0.8	< 0.0

[a] * = Crop species.
[b] Maya names precede Spanish names. English names included for crops only.
[c] Either Caesalpinia sp. or Pithecellobium sp.

APPENDIX Q

PERCENT OCCURRENCE (% OCC.) AND VOLUME (% VOL.) OF WHITE-LIPPED PECCARY FOOD ITEMS BASED ON AN ANALYSIS OF THE CONTENTS OF THREE STOMACHS (TOTAL VOLUME ANALYZED = 208.0 ML)

Food item[a]	Family	Local names[b]	% Occ.	% Vol.
Brosimum alicastrum Swartz	Moraceae	*Ox* *Ramón*	100.0	87.7
Unidentified plant	Unidentified	*Can pe tzu* ---	100.0	4.6
Psychotria sp.	Rubiaceae	--- *Kanan verde*	100.0	1.0
Acoelorrhaphe wrightii (Griseb. & Wendl.) Wendl. ex Beccari	Palmae	*Taxiste* ---	66.7	3.8
Carica papaya L.	Cariacaceae	*Pu chich & Puut* *Papaya*	66.7	1.4
Cissus sicyoides L.	Vitaceae	*Ta cani* ---	66.7	1.0
Unidentified plant	Unidentified	--- ---	66.7	< 0.0
Malmea depressa (Baillon) R.E. Fries	Annonaceae	*Elemuy* ---	33.3	0.5
Vitex gaumeri Greenm.	Verbenaceae	*Yaxnic* ---	33.3	< 0.0
Manilkara zapota (L.) v. Royen	Sapotaceae	*Ya* *Chicozapote*	33.3	< 0.0
Dalbergia glabra (Miller) Standl.	Leguminosae	*Muk* ---	33.3	< 0.0
Hamelia patens Jacq.	Rubiaceae	*Scanam* *Kanan rojo*	33.3	< 0.0
Trophis racemosa (L.) Urban	Moraceae	*Sak ox* ---	33.3	< 0.0
Unidentified mushroom	Class Basidiomycetes	--- *Hongo*	33.3	< 0.0
Unidentified insect	Order Odonata	*Turis* *Libelula*	33.3	< 0.0
Unidentified slug	Class Gastropoda	--- *Gusano*	33.3	< 0.0
Misc. mammal tissue (skin & hair)	Class Mammalia	--- ---	33.3	< 0.0

[a] * = Crop species.
[b] Maya names precede Spanish names. English names included for crops only.

APPENDIX R

PERCENT OCCURRENCE (% OCC.) AND VOLUME (% VOL.) OF COLLARED PECCARY FOOD ITEMS BASED ON AN ANALYSIS OF THE CONTENTS OF 29 STOMACHS (TOTAL VOLUME ANALYZED = 1829.0 ML)

Food item[a]	Family	Local names[b]	% Occ.	% Vol.
Psychotria sp.	Rubiaceae	--- *Kanan verde*	79.3	23.8
Brosimum alicastrum Swartz	Moraceae	*Ox* *Ramón*	75.9	15.2
Carica papaya L.	Cariacaceae	*Pu chich & Puut* *Papaya*	48.3	11.2
Misc. mammal tissue (skin & hair)	Class Mammalia	--- ---	48.3	< 0.0
Unidentified plant	Unidentified	--- ---	31.0	0.2
Byrsonima bucidaefolia Standl.	Malpighiaceae	*Sac paa* *Nance agrio*	27.6	11.7
Cissus sicyoides L.	Vitaceae	*Ta cani* ---	27.6	0.9
Metopium brownei (Jacq.) Urban	Anacardiaceae	*Chechem* ---	20.7	1.4
Vitex gaumeri Greenm.	Verbenaceae	*Yaxnic* ---	20.7	0.4
Cucurbita moschata Duch.*	Cucurbitaceae	*Ku'um* *Calabaza* Squash	13.8	5.9
Diospyros sp.	Ebenaceae	*Silil &* *Uh chuche* ---	13.8	3.1
Unidentified plant	Unidentified	*Can pe tzu* ---	13.8	3.1
Zea mays L.*	Gramineae	*Nall* *Maiz* Corn	10.3	12.8
Ipomoea batatas (L.) Lam.*	Convolvulaceae	*Is* *Camote* Sweet potato	10.3	6.6
Desmoncus quasillarius H. Bartlett	Palmae	*Bayal* ---	10.3	2.8
Unidentified slug	Order Gastropoda	--- *Gusano*	10.3	< 0.0
Thevetia gaumeri Hemsl.	Apocynaceae	*Akitz* ---	10.3	< 0.0

Food item[a]	Family	Local names[b]	% Occ.	% Vol.
Dalbergia glabra (Miller) Standl.	Leguminosae	*Muk* ---	10.3	< 0.0
Malmea depressa (Baillon) R.E. Fires	Annonaceae	*Elemuy* ---	10.3	< 0.0
Trophis racemosa (L.) Urban	Moraceae	*Sak ox* ---	6.9	< 0.0
Unidentified plant	Unidentified	*Chico loro* ---	6.9	< 0.0
Ipomoea triloba L.	Convolvulaceae	*Is a kil* ---	6.9	< 0.0
Sarcostemma bilobum H. & A.	Asclepiadaceae	*Tzotz ca bi* ---	3.4	0.3
Scleria lithosperma (L.) Swartz*[c]	Cyperaceae	*Ak nom* *Zacate* ---	3.4	0.2
Sabal yapa C. Wright ex Beccari	Palmae	*Bom & Xa'an* *Huano*	3.4	0.1
Bauhinia divaricata L.	Leguminosae	*Tzu run toc* ---	3.4	< 0.0
Dipholis salicifolia (L.) A. DC.	Sapotaceae	*Ik che &* *Tzi tzi yah* ---	3.4	< 0.0
Byrsonima crassifolia (L.) HBK.	Malpighiaceae	*Chi* *Nance dulce*	3.4	< 0.0
Dendropanax arboreus (L.) Dcne. & Planch.	Araliaceae	*Sac chacá* ---	3.4	< 0.0
Nectandra sp.	Lauraceae	*Ho choc* ---	3.4	< 0.0
Unidentified plant	Class Basidiomycetes	--- *Hongo*	3.4	< 0.0
Unidentified plant	Unidentified	*Ni te* ---	3.4	< 0.0
Caesalpinia yucatanensis Greenm.	Leguminosae	*Tah kin che* ---	3.4	< 0.0
Coccoloba acapulcensis Standl.	Polygonaceae	*To'yub* ---	3.4	< 0.0
Unidentified insect	Class Orthoptera	*Kuklin (?)* ---	3.4	< 0.0

Food item[a]	Family	Local names[b]	% Occ.	% Vol.
Unidentified reptile	Class Reptilia	--- *Tortuga*	3.4	< 0.0
Unidentified reptile	Class Reptilia	*Kan* *Culebra*	3.4	< 0.0
Plastic, Rocks, & Soil	---	---	3.4	< 0.0

[a] * = Crop species.
[b] Maya names precede Spanish names. English names included for crops only.
[c] *Ak nom/Zacate* apparently is not the same as *Zu uc/Zacate* (unidentified species).

APPENDIX S
PERCENT OCCURRENCE (% OCC.) AND VOLUME (% VOL.) OF BROCKET DEER FOOD ITEMS BASED ON AN ANALYSIS OF THE CONTENTS OF EIGHT STOMACHS (TOTAL VOLUME ANALYZED = 446.0 ML)

Food item[a]	Family	Local names[b]	% Occ.	% Vol.
Psychotria sp.	Rubiaceae	--- *Kanan verde*	87.5	58.3
Brosimum alicastrum Swartz	Moraceae	*Ox* *Ramón*	62.5	1.6
Eugenia sp.	Myrtaceae	*Sip che* ---	50.0	0.4
Unidentified plant	Unidentified	--- ---	50.0	0.3
Trophis racemosa (L.) Urban	Moraceae	*Sak ox* ---	37.5	1.1
Manilkara zapota (L.) v. Royen	Sapotaceae	*Ya* *Chicozapote*	37.5	0.7
Misc. mammal tissue (skin & hair)	Class Mammalia	--- ---	37.5	< 0.0
Sarcostemma bilobum H. & A.	Asclepiadaceae	*Tzotz cabi* ---	25.0	9.2
Galactia striata (Jacq.) Urban	Leguminosae	*Ka xa yuk* ---	25.0	8.1
Sapindaceae	Sapindaceae	*Tzool* ---	25.0	1.6
Bauhinia divaricata L.	Leguminosae	*Tzu run tok* ---	25.0	0.9
Carica papaya L.	Cariacaceae	*Pu chich &* *Puut* *Papaya*	25.0	0.2
Thevetia gaumeri Hemsl.	Apocynaceae	*Akitz* ---	25.0	< 0.0
Unidentified plant	Class Basidiomycetes	--- *Hongo*	25.0	< 0.0
Trichilia hirta L.	Meliaceae	*Chili cha han* ---	12.5	11.7
Acoelorrhaphe wrightii (Griseb. & Wendl.) Wendl. ex Beccari	Palmae	*Taxiste* ---	12.5	2.2
Swartzia cubensis (Britton & Wils.) Standl.	Leguminosae	*Ka taal ox* ---	12.5	0.9
Byrsonima bucidaefolia Standl.	Malpighiaceae	*Sac paa* *Nance agrio*	12.5	0.7

Food item[a]	Family	Local names[b]	% Occ.	% Vol.
Unidentified plant	Unidentified	*Chit ku'uk* ---	12.5	0.4
Unidentified plant	Unidentified	*Chico loro* ---	12.5	0.4
Acanthocereus pentagonus (L.) Britton & Rose	Cactaceae	*Pi ta ha ya* ---	12.5	0.4
Colubrina sp.	Rhamnaceae	*Bu klun che* ---	12.5	0.3
Metopium brownei (Jacq.) Urban	Anacardiaceae	*Chechem* ---	12.5	0.2
Scleria lithosperma (L.) Swartz*[c]	Cyperaceae	*Ak nom* *Zacate* ---	12.5	0.2
Nectandra sanguinea Rottb.	Lauraceae	*Ho choc* ---	12.5	< 0.0
Vitex gaumeri Greenm.	Verbenaceae	*Yaxnic* ---	12.5	< 0.0
Unidentified plant[3]	Unidentified	*Zu uc* *Zacate*	12.5	< 0.0
Unidentified plant	Unidentified	*Can pe tzu* ---	12.5	< 0.0
Cydista potosina (Schum. & Loes.) Loes.	Bignoniaceae	*E ki xil* ---	12.5	< 0.0
Ipomoea triloba L.	Convolvulaceae	*Is a kil* ---	12.5	< 0.0
Lysiloma latisiliqua (L.) Benth.	Leguminosae	*Tzalam* ---	12.5	< 0.0
Plastic, Rocks, & Soil	---	---	12.5	< 0.0

[a] * = Crop species.
[b] Maya names precede Spanish names. English names included for crops only.
[c] *Ak nom/Zacate* apparently is not the same as *Zu uc/Zacate* (unidentified species).

APPENDIX T
PERCENT OCCURRENCE (% OCC.) AND VOLUME (% VOL.) OF WHITE-TAILED DEER FOOD ITEMS BASED ON AN ANALYSIS OF THE CONTENTS OF 11 STOMACHS (TOTAL VOLUME ANALYZED = 601.0 ML)

Food item[a]	Family	Local names[b]	% Occ.	% Vol.
Psychotria sp.	Rubiaceae	--- *Kanan verde*	72.7	42.7
Unidentified plant	Unidentified	--- ---	54.5	0.7
Trophis racemosa (L.) Urban	Moraceae	*Sak ox* ---	45.5	7.7
Brosimum alicastrum Swartz	Moraceae	*Ox* *Ramón*	45.5	1.0
Galactia striata (Jacq.) Urban	Leguminosae	*Ka xa yuk* ---	36.4	5.6
Ipomoea triloba L.	Convolvulaceae	*Is a kil* ---	36.4	0.7
Eugenia sp.	Myrtaceae	*Sip che* ---	36.4	0.6
Misc. mammal tissue (skin & hair)	Class Mammalia	---	36.4	< 0.0
Euphorbia heterophylla L.	Euphorbiaceae	*Jobon kak* ---	27.3	9.4
Sarcostemma bilobum H. & A.	Asclepiadaceae	*Tzotz ca bi* ---	27.3	6.8
Momordica charantia L.	Cucurbitaceae	*Yoch way* ---	27.3	0.8
Hamelia patens Jacq.	Rubiaceae	*Scanam* *Kanan rojo*	27.3	0.4
Dalbergia glabra (Miller) Standl.	Leguminosae	*Muk* ---	27.3	< 0.0
Chrysophyllum mexicanum Brand. ex Standl.	Sapotaceae	*Chi keh* ---	18.2	< 0.0
Lysiloma latisiliqua (L.) Benth.	Leguminosae	*Tzalam* ---	18.2	< 0.0
Unidentified plant[c]	Unidentified	*Zu uc* *Zacate*	9.1	9.4
Phaseolus vulgaris L.*	Leguminosae	Buul Frijol Kidney bean	9.1	9.0
Byrsonima bucidaefolia Standl.	Malpighiaceae	*Sac paa* *Nance agrio*	9.1	1.7

Food item[a]	Family	Local names[b]	% Occ.	% Vol.
Byrsonima crassifolia (L.) HBK.	Malpighiaceae	*Chi* *Nance dulce*	9.1	1.5
Protium copal (Schlecht. & Cham.) Engl.	Burseraceae	*Po on* *Copal*	9.1	0.5
Nyctaginaceae	Nyctaginaceae	*Tatzi* ---	9.1	0.4
Unidentified plant	Unidentified	*Chi lar* ---	9.1	0.3
Ficus sp.	Moraceae	*Ha huay &* *Sac ha huay* ---	9.1	0.2
Croton glabellus L.	Euphorbiaceae	*Peres cutz* *Oregono wech*	9.1	0.2
Manilkara zapota (L.) v. Royen	Sapotaceae	*Ya* *Chicozapote*	9.1	0.2
Exothea diphylla (Standl.) Lundell	Sapindaceae	*Wa yun kox* ---	9.1	0.1
Unidentified plant	Unidentified	*Can pe tzu* ---	9.1	0.1
Smilax mexicana Griseb.	Smilacaceae	*Koke* ---	9.1	< 0.0
Vitex gaumeri Greenm.	Verbenaceae	*Yaxnic* ---	9.1	< 0.0
Thevetia gaumeri Hemsl.	Apocynaceae	*Akitz* ---	9.1	< 0.0
Carica papaya L.	Cariacaceae	*Pu chich & Puut* *Papaya*	9.1	< 0.0
Diospyros sp.	Ebenaceae	*Silil &* *Uh chu che* ---	9.1	< 0.0
Sapindaceae	Sapindaceae	*Tzool* ---	9.1	< 0.0
Petrea arborea HBK.	Verbenaceae	*Yoch op chimin* ---	9.1	< 0.0
Celtis iguanaea (Jacq.) Sarg.	Ulmaceae	*Chich mu uk* ---	9.1	< 0.0
Unidentified plant	Unidentified	*Chit ku'uk*	9.1	< 0.0

Food item[a]	Family	Local names[b]	% Occ.	% Vol.
Paullinia pinnata L.	Sapindaceae	*Chac tzacan* ---	9.1	< 0.0
Cydista potosina (Schum. & Loes.) Loes.	Bignoniaceae	*E ki xil* ---	9.1	< 0.0
Mimosa pigra L.	Leguminosae	*Mu tzil* ---	9.1	< 0.0
Amphilophium peniculatus (?)	Bignoniaceae	*Sit wech* ---	9.1	< 0.0
Forchhammeria trifoliata Radlk.	Capparidaceae	--- *Tres marias*	9.1	< 0.0
Unidentified animal (bone)	Phylum Chordata	--- ---	9.1	< 0.0
Plastic, Rocks, & Soil	---	---	9.1	< 0.0

[a] * = Crop species.
[b] Maya names precede Spanish names. English names included for crops only.
[c] *Zu uc/Zacate* apparently is not the same as *Ak nom/Zacate* (Scleria lithosperma).

APPENDIX U

PERCENT OCCURRENCE (% OCC.) AND VOLUME (% VOL.) OF THICKET TINAMOU FOOD ITEMS BASED ON AN ANALYSIS OF THE CONTENTS OF THREE STOMACHS (ESOPHAGUS, CROP, PROVENTRICULUS, AND GIZZARD; TOTAL VOLUME ANALYZED = 13.0 ML)

Food item[a]	Family	Local names[b]	% Occ.	% Vol.
Unidentified plant	Unidentified	--- ---	100.0	69.2
Chrysophyllum mexicanum Brand. ex Standl.	Sapotaceae	*Chi keh* ---	66.7	26.9
Galactia striata (Jacq.) Urban	Leguminosae	*Ka xa yuk* ---	66.7	< 0.0
Unidentified insect	Class Insecta	*Kuklin (?)* ---	33.3	3.8
Unidentified plant	Unidentified	*Xeret* ---	33.3	< 0.0
Scleria lithosperma (L.) Swartz*[c]	Cyperaceae	*Ak nom* *Zacate*	33.3	< 0.0
Sarcostemma bilobum H. & A.	Asclepiadaceae	*Tzotz ca bi* ---	33.3	< 0.0

[a] * = Crop species.
[b] Maya names precede Spanish names. English names included for crops only.
[c] *Ak nom/Zacate* apparently is not the same as *Zu uc/Zacate* (unidentified species).

APPENDIX V

PERCENT OCCURRENCE (% OCC.) AND VOLUME (% VOL.) OF GREAT CURASSOW FOOD ITEMS BASED ON AN ANALYSIS OF THE CONTENTS OF 13 STOMACHS (ESOPHAGUS, CROP, PROVENTRICULUS, AND GIZZARD; TOTAL VOLUME ANALYZED = 694.0 ML)

Food item[a]	Family	Local names[b]	% Occ.	% Vol.
Plastic, Rocks, & Soil	---	---	61.5	2.5
Diospyros sp.	Ebenaceae	*Silil & Uh chu che* ---	53.8	12.5
Manilkara zapota (L.) v. Royen	Sapotaceae	*Ya* *Chicozapote*	53.8	5.6
Brosimum alicastrum Swartz	Moraceae	*Ox* *Ramón*	46.2	34.5
Unidentified plant	Unidentified	--- ---	38.5	1.1
Dipholis salicifolia (L.) A. DC.	Sapotaceae	*Ik che & Tzi tzi yah* ---	38.5	0.5
Pouteria unilocularis (Donn. Smith) Baehni	Sapotaceae	*Chak ya* ---	23.1	14.9
Leguminosae[c]	Leguminosae	*Chok che* ---	23.1	3.7
Galactia striata (Jacq.) Urban	Leguminosae	*Ka xa yuk* ---	23.1	0.1
Coccoloba acapulcensis Standl.	Polygonaceae	*To'yub* ---	15.4	7.9
Phaseolus vulgaris L.*	Leguminosae	Buul Frijol Kidney bean	15.4	4.2
Sabal yapa C. Wright ex Beccari	Palmae	*Bom & Xa'an* *Huano*	15.4	3.9
Psychotria sp.	Rubiaceae	--- *Kanan verde*	15.4	0.9
Thevetia gaumeri Hemsl.	Apocynaceae	*Akitz* ---	15.4	0.2
Metopium brownei (Jacq.) Urban	Anacardiaceae	*Chechem* ---	7.7	2.9
Unidentified plant	Unidentified	*Ko lop* ---	7.7	1.4
Sarcostemma bilobum H. & A.	Asclepiadaceae	*Tzotz ca bi* ---	7.7	1.3
Coccoloba sp.	Polygonaceae	*Chich bob* ---	7.7	0.9

Food item[a]	Family	Local names[b]	% Occ.	% Vol.
Unidentified plant	Unidentified	*Ka ni macal* ---	7.7	0.7
Unidentified plant[d]	Unidentified	*Zu uc* *Zacate*	7.7	0.1
Momordica charantia L.	Cucurbitaceae	*Yoch way* ---	7.7	0.1
Cucurbita moschata Duch.*	Cucurbitaceae	*Ku'um* *Calabaza* *Squash*	7.7	< 0.0
Allophylus cominia (L.) Swartz	Sapindaceae	*Ik batch* ---	7.7	< 0.0
Scleria lithosperma (L.) Swartz*[d]	Cyperaceae	*Ak nom* *Zacate* ---	7.7	< 0.0
Unidentified bird	Class Aves	--- ---	7.7	< 0.0
Misc. mammal tissue (skin & hair)	Class Mammalia	--- ---	7.7	< 0.0

[a] * = Crop species.
[b] Maya names precede Spanish names. English names included for crops only.
[c] Either Caesalpinia sp. or Pithecellobium sp.
[d] *Zu uc/Zacate* (unidentified species) apparently is not the same as *Ak nom/Zacate* (Scleria lithosperma).

APPENDIX W

PERCENT OCCURRENCE (% OCC.) AND VOLUME (% VOL.) OF PLAIN CHACHALACA FOOD ITEMS BASED ON AN ANALYSIS OF THE CONTENTS OF 21 STOMACHS (ESOPHAGUS, CROP, PROVENTRICULUS, AND GIZZARD; TOTAL VOLUME ANALYZED = 329.5 ML)

Food item[a]	Family	Local names[b]	% Occ.	% Vol.
Chrysophyllum mexicanum Brand. ex Standl.	Sapotaceae	*Chi keh* ---	23.8	18.1
Metopium brownei (Jacq.) Urban	Anacardiaceae	*Chechem* ---	23.8	9.4
Sabal yapa C. Wright ex Beccari	Palmae	*Bom & Xa'an* *Huano*	19.0	17.9
Allophylus cominia (L.) Swartz	Sapindaceae	*Ik batch* ---	14.3	11.8
Trema micrantha (L.) Blume	Ulmaceae	*Payux* ---	14.3	1.8
Unidentified plant	Unidentified	*Xeret* ---	9.5	5.8
Psychotria sp.	Rubiaceae	--- *Kanan verde*	9.5	5.5
Thevetia wrightii Hemsl.	Apocynaceae	*Akitz* ---	9.5	1.2
Exothea diphylla (Standl.) Lundell	Sapindaceae	*Wa yun kox* ---	9.5	0.2
Scleria lithosperma (L.) Swartz*[c]	Cyperaceae	*Ak nom* *Zacate* ---	4.8	6.7
Celtis iguanaea (Jacq.) Sarg.	Ulmaceae	*Chich mu uk* ---	4.8	6.1
Cecropia obtusifolia Bert.	Moraceae	*Guarumo* ---	4.8	4.9
Mikania sp.	Compositae	*Okin sukuu* ---	4.8	3.9
Hamelia patens Jacq.	Rubiaceae	*Scanam* *Kanan rojo*	4.8	3.0
Cestrum sp. (?)	Solanaceae	*A ka xiu* ---	4.8	2.4
Astronium graveolens Jacq.	Anacardiaceae	*Ku lin che* ---	4.8	1.2
Ficus sp.	Moraceae	*Ha huay &* *Sac ha huay* ---	4.8	0.2
Eugenia mayana Standl.	Myrtaceae	*Sac lob che* ---	4.8	< 0.0

Food item[a]	Family	Local names[b]	% Occ.	% Vol.
Unidentified plant	Unidentified	*Tzitz* ---	4.8	< 0.0
Unidentified plant	Unidentified	--- ---	4.8	< 0.0

[a] * = Crop species.
[b] Maya names precede Spanish names. English names included for crops only.
[c] *Ak nom/Zacate* apparently is not the same as *Zu uc/Zacate* (unidentified species).

APPENDIX X

PERCENT OCCURRENCE (% OCC.) AND VOLUME (% VOL.) OF OCELLATED TURKEY FOOD ITEMS BASED ON AN ANALYSIS OF THE CONTENTS OF FIVE STOMACHS (ESOPHAGUS, CROP, PROVENTRICULUS, AND GIZZARD; TOTAL VOLUME ANALYZED = 211.5 ML)

Food item[a]	Family	Local names[b]	% Occ.	% Vol.
Scleria lithosperma (L.) Swartz*[c]	Cyperaceae	*Ak nom* *Zacate* *Zacate*	60.0	7.6
Psychotria sp.	Rubiaceae	--- *Kana verde*	60.0	5.0
Plastic, Rocks, & Soil	---	---	60.0	3.3
Unidentified plant	Unidentified	--- ---	60.0	3.3
Zea mays L.*	Gramineae	*Nall* *Maiz* Corn	40.0	24.6
Manilkara zapota (L.) v. Royen	Sapotaceae	*Ya* *Chicozapote*	40.0	12.5
Unidentified plant	Unidentified	*Tzitz* ---	40.0	0.5
Phaseolus vulgaris L.*	Leguminosae	*Buul* *Frijol* Kidney bean	20.0	18.9
Allophylus cominia (L.) Swartz	Sapindaceae	*Ik batch* ---	20.0	8.0
Byrsonima bucidaefolia Standl.	Malpighiaceae	*Sac paa* *Nance agrio*	20.0	6.4
Unidentified plant	Unidentified	--- *Hierba mora*	20.0	4.3
Unidentified snail	Class Gastropoda	--- *Caracol*	20.0	3.8
Galactia striata (Jacq.) Urban	Leguminosae	*Ka xa yuk* ---	20.0	0.7
Unidentified plant	Unidentified	*Can pe tzu* ---	20.0	0.5
Ficus sp.	Moraceae	*Ha huay &* *Sac ha huay* ---	20.0	0.5
Trema micrantha (L.) Blume	Ulmaceae	*Payux* ---	20.0	0.2
Sabal yapa C. Wright ex Beccari	Palmae	*Bom & Xa'an* *Huano*	20.0	< 0.0

[a] * = Crop species.
[b] Maya names precede Spanish names. English names included for crops only.
[c] *Ak nom/Zacate* apparently is not the same as *Zu uc/Zacate* (unidentified species).

APPENDIX Y
GARDEN INTERVIEW FORM

1. Record number?_____

2. Garden number?_____

3. Date of the interview (m/d/y)?_____/_____/_____

4. Interviewer?_____

5. Interviewee?_____

5.3. Did the interviewee plant a garden (1 = yes, 2 = no)?_____

6. Garden size (number of "mecates")?_____

7. Number of years that the site has been used as a garden immediately prior to this planting?_____

7.1. Date that garden clearing began (m/d/y)?_____/_____/_____

7.2. Date that the garden was burned (m/d/y)?_____/_____/_____

8. Date that planting began (m/d/y)?_____/_____/_____

For crops listed in 9-21, crops planted in garden (1 = yes, planted; 2 = no, not planted; and 3 = yes will plant, but later in the season):

9. Squash?_____

10. Sweet potato?_____

11. Chaya?_____

12. Chile pepper?_____

13. Kidney bean?_____

14. Fruits (assorted)?_____

15. Ibes?_____

16. Jícama?_____

17. Lentejas?_____

18. Yam?_____

19. Corn?_____

20. Yuca?_____

21. Other?_____

For garden sides indicated in 35-38, the type of vegetation around the garden (1 = *hortaliza*, 2 = *milpa*, 3 = *huerto familiar*, 4 = *huamil/hubche*, 5 = *monte alto*, 6 = *monte bajo*, 7 = *sabana*, 9 = *otro*:__________

35. North side?_____

36. East side?_____

37. South side?_____

38. West side?_____

39. Direction and distance of the garden from X-Hazil Sur?__________

39.1. Name of the garden site?__________

40. Were there habitat disturbances in the vicinity of the garden during the growing season (1 = yes, 2 = no)?_____

40.1. If yes, what type of disturbances (1 = fire, 2 = timber harvest)?_____

For garden sides indicated in 41-44, owners of gardens within 500 m (first and last names)?

41. North side?__________ 43. South side?__________

42. East side?__________ 44. West side?__________

45. Does the gardener work alone (1) or in a group (2)?_____

46. If in a group, how many people assist the gardener?_____

47. If in a group, the names and relationship of the assistants to the gardener?_______________

48. What species of animal is the most serious crop predator in the garden (1 = *armadillo*, 2 = *cabrito*, 3 = *jabalí*, 4 = *loros/pájaros*, 5 = *mapache*, 6 = *tejón*, 7 = *tepescuintle*, 8 = *venado cola blanca*, 9 = *sereke*, 10 = *otro*)?

49. Will you need to replant the garden due to bad weather (1 = yes, 2 = no, 3 = "depends on the rains")?_____

50. Frequency with which the gardener hunts in the garden (1 = "a lot" [≥ 4 times per month], 2 = "once in a while" [2-3 times per month], 3 = "rarely or never" [0-1 times per month])?_____

51. Interviewer notes.

52. Site map (indicate adjacent gardens and direction, distance, and surrounding vegetation for this specific garden).

APPENDIX Z
GAME SPECIES AND MAIN CROP SPECIES AT EJIDO X-HAZIL Y ANEXOS, QUINTANA ROO, MEXICO, DURING 1989-1990

Scientific name	Class or Order/Family[a]	Common name
a) Game species[b]		
Orthogeomys hispidus[c]	Mammalia/Geomyidae	Pocket gopher
Agouti paca	Mammalia/Agoutidae	Paca
Dasyprocta punctata	Mammalia/Dasyproctidae	Agouti
Nasua nasua	Mammalia/Procyonidae	Coati
Tayassu pecari	Mammalia/Tayassuidae	White-lipped peccary
Tayassu tajacu	Mammalia/Tayassuidae	Collared peccary
Mazama americana	Mammalia/Cervidae	Brocket deer
Odocoileus virginianus	Mammalia/Cervidae	White-tailed deer
Crypturellus cinnamomeus	Aves/Tinamidae	Thicket tinamou
Crax rubra	Aves/Cracidae	Great curassow
Ortalis vetula	Aves/Cracidae	Plain chachalaca
Agriocharis ocellata	Aves/Meleagrididae	Ocellated turkey
b) Main crop species[d]		
Ipomoea batatas	Tubiflorales/ Convolvulaceae	Sweet potato
Cucurbita moschata	Campanulales/ Cucurbitaceae	Squash
Dioscorea alata[e]	Liliales/Dioscoreaceae	Yam
Cnidoscolus chayamansa	Geraniales/ Euphorbiaceae	Chaya
Manihot esculenta	Geraniales/ Euphorbiaceae	Yuca
Cajanus cajan	Rosales/ Fabaceae (Leguminosae)	Lentil
Zea mays	Graminales/Gramineae	Corn
Pachyrrhizus erosus var. *palmatilobus*	Rosales/Leguminosae	Jícama
Phaseolus lunatus	Rosales/Leguminosae	Ib bean
Phaseolus vulgaris	Rosales/Leguminosae	Kidney bean

Scientific name	Class or Order/Family[a]	Common name
Capsicum annum	Tubiflorales/ Solanaceae	Chili
Other[f]		
Fruits[g]		

[a] Class and Family for game species (sorted taxonomically). Order and Family for main crop species (sorted alphabetically by Family).

[b] Game species based on hunter survey during 1989-1990 (see Chapter 3).

[c] Pocket gophers were excluded from food item analyses because stomach contents were not readily available or identifiable.

[d] Main crop species based on gardener survey during 1989-1990 (see Chapter 6).

[e] The term "yam" refers primarily to *Dioscorea alata*, but X-Hazil Sur residents also cultivated another *macal* that was not identified, but may be either *Colocasia esculenta* or *Xanthosoma yucatanense* (Arales/Araceae).

[f] The term "other" refers primarily to zacate (*Scleria lithosperma* [Graminales/Cyperaceae]), but also includes an unidentified bean (*Phaseolus* sp.), an unidentified squash (*Cucurbita* sp.), and a an unidentified cucumber (*Cucumis* sp.).

[g] The term "fruits" was used by X-Hazil Sur residents to refer to several species of plants. For analytical purposes, these species were combined, but included the following: Anacardiaceae, mango (*Mangifera indica*); Bromeliaceae, pineapple (*Ananas sativa*); Cariacaceae, papaya (*Carica papaya*); Cucurbitaceae, watermelon (*Citrullus vulgaris*); Gramineae, sugarcane (*Saccharum officinarum*); Lauraceae, avocado (*Persea americana*); Leguminosae, peanut (*Arachis hypodaea*); Musaceae, banana (*Musa* sp.); Rutaceae, lime (*Citrus aurantifolia*) and orange (*C. sinensis*); and Sapotaceae (*Pouteria mammosa*).

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BIOGRAPHICAL SKETCH

Jeffrey P. Jorgenson was born on 15 July 1951 in a small town in west central Minnesota. His earliest memories include enjoyable holiday gatherings with relatives, several unexpected moves with his family to new towns, and frequent summer vacations at farms belonging to his grandparents or other relatives. During these vacations he learned how to drive a tractor and stalk wild animals. These were pleasant times.

After graduating from Benson Senior High School in 1969, he attended Augustana College (1969-1973), Sioux Falls, South Dakota, where he became interested in plants and bird watching. Subsequently he attended the University of North Dakota (1973-1977), Grand Forks, North Dakota, and earned the Master of Science degree. He conducted research on habitat use and movement patterns of the greater prairie chicken (*Tympanuchus cupido pinnatus*). In 1976 Jorgenson became a Peace Corps Volunteer and was assigned to Colombia (1976-1979). During the first part of his Peace Corps service he studied the ecology and behavior of the capybara (*Hydrochaeris hydrochaeris*), the world's largest rodent, while living on a cattle ranch in the northeastern part of the country. Later, he moved to a site in the Andes Mountains, near Santafé de Bogotá, and conducted small mammal surveys. At that time Jorgenson also became interested in the ecology and conservation status of the spectacled bear (*Tremarctos ornatus*). Upon completion of his Peace Corps service in 1979, Jorgenson was married to Amanda Barrera Rodríguez, whom he had met in Bogotá.

Upon his return to the United States in 1979, Jorgenson worked briefly with the Bureau of Reclamation in North Dakota, on the Garrison Diversion Project, before accepting a position in Washington, DC, with the Fish and Wildlife Service (1980-1986). In Washington, he worked as a biologist in the office that served as the U.S. Management Authority for the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Jorgenson's knowledge of Spanish and his interest in international conservation problems were extremely useful at that time, especially when he served as special assistant to the U.S. CITES delegation at the 1985 meeting in Buenos Aires.

In 1986 Jorgenson was accepted into the doctoral program at the University of Florida, where his interest in subsistence hunting by indigenous peoples developed. During his field research, Jorgenson lived for two years in a Maya Indian community in southeastern Mexico. In addition to the research, Jorgenson became the village typist, pawn broker, photographer, and ambulance service. Prior to leaving Mexico, he and his wife became the godparents of a young Maya girl, Nora Rubí Poot Uc. Upon his graduation from the University of Florida, Jorgenson would like to continue working in Latin America, conducting research that will be useful in solving critically important conservation problems in the Neotropics.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Kent H. Redford, Chair
Associate Professor of Forest Resources and Conservation

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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This dissertation was submitted to the Graduate Faculty of the School of Forest Resources and Conservation in the College of Agriculture and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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